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This report contains summaries of 70 projects that were completed under the Army's Manufacturing Methods and Technology (MMT) program. The MMT program was established to upgrade manufacturing facilities used for the production of Army materiel. The summaries highlight the accomplishments and benefits of the projects and the implementation actions underway or planned. Points of contact are also provided for those who are interested in obtaining additional information.

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U.S. ARMY

MATERIEL DEVELOPMENT
AND READINESS COMMAND

MANUFACTURING METHODS & TECHNOLOGY

PROJECT SUMMARY REPORTS

(RCS DRCMT-302)

PREPARED BY

JUNE 1979

USA INDUSTRIAL BASE ENGINEERING ACTIVITY

MANUFACTURING TECHNOLOGY DIVISION

ROCK ISLAND, ILLINOIS 61299

DEPARTMENT OF THE ARMY
US ARMY INDUSTRIAL BASE ENGINEERING ACTIVITY
ROCK ISLAND, ILLINOIS 61299

DRXIB-MT

23 JUL 1979

SUBJECT: Manufacturing Methods and Technology Program
Project Summary Report (RCS DRCMT-302)

SEE DISTRIBUTION (Appendix II to Inclosure 1)

1. In compliance with AR 700-90, C1, dated 10 March 1977, the Industrial Base Engineering Activity (IBEA) has prepared the inclosed Project Summary Report.

2. This Project Summary Report is a compilation of MMT Summary Reports prepared by IBEA based on information submitted by DARCOM major subordinate commands and project managers. These projects represent a cross-section of the type of efforts that are being conducted under the Army's Manufacturing Methods and Technology Program. Persons who are interested in the details of a project should contact the project officer indicated at the conclusion of each individual report.

3. Additional copies of this report may be obtained by written request to the Defense Documentation Center, ATTN: TSR-1, Cameron Station, Alexandria, VA, 22314.

J R Gallaugher

J. R. GALLAUGHER
Director,
Industrial Base Engineering Activity

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TABLE OF CONTENTS

Table of Contents (Continued)

Table of Contents (Continued)

Table of Contents (Continued)

INTRODUCTION

Background

The Manufacturing Methods and Technology (MMT) Program was established to upgrade manufacturing facilities used for the production of Army materiel, and as such, provides direct support to the Industrial Preparedness Program. The Manufacturing Methods and Technology Program consists of projects which provide engineering effort for the establishment of manufacturing processes, techniques, and equipment by the Government or private industry to provide for timely, reliable, economical, and high-quality quantity production means. The projects are intended to bridge the gap between demonstrated feasibility and full-scale production. The projects are normally broad based in application, are production oriented, and are expected to result in a practical process for production. The projects do not normally include the application of existing processes, techniques, or equipment to the manufacture of specific systems, components, or end items, nor do they apply to a specific weapon system development or a product improvement program.

MMT Program Participation

MMT Programs are prepared annually by DARCOM major subordinate commands. These programs strive for the timely establishment or improvement of the manufacturing processes, techniques, or equipment required to support current and project programs.

Project proposals (Exhibits P-16) are submitted to the appropriate MMT Program Office. A list of offices is provided in Appendix I. Additional information concerning participation in the MMT Program can be obtained by contacting an office listed or by contacting Mr. James Carstens, AUTOVON 793-5113, or Commercial (309) 794-5113, Industrial Base Engineering Activity, Rock Island, IL 61299.

In anticipation of the lengthy DOD funding cycles, projects must be submitted in sufficient time for their review and appraisal prior to the release of funds at the beginning of each fiscal year. Participants in the program must describe manufacturing problems and proposed solutions in Exhibit P-16 formats (see AR 700-90, 4 August 1975, for instructions). Project manager offices should submit their proposals to the command that will have mission responsibility for the end item that is being developed.

Contents

This report contains summaries of 70 completed projects that were funded by the MMT Program. The summaries are prepared from Project Status Reports (RCS DRCMT-301) and Final Technical Reports submitted by organizations executing the MMT projects. The summaries highlight the accomplishments and benefits of the projects and the implementation actions under way or planned. Points of contact are also provided for those interested in obtaining additional information.

The MMT Program addresses the entire breadth of the Army production base and, therefore, involves many technical areas. For ease of referral, the project summaries are grouped into six technical areas. The technical areas are CAD/CAM, Electronics, Inspection and Test, Metals, Munitions, and Non-Metals.

The Summary Reports are prepared and published for the Office of Manufacturing Technology, DARCOM, by the Manufacturing Technology Division of the Army Industrial Base Engineering Activity, (IBEA) in compliance with AR 700-90, C1.

COMPUTER AIDED DESIGN/
COMPUTER AIDED MANUFACTURING
(CAD/CAM)

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project A74 202N titled, "Computer-Aided Pattern Fabrication Techniques" was completed by the US Army Natick Research and Development Command in July 1976 at a cost of $300,000.

BACKGROUND

Clothing pattern making is highly dependent on human skills which reside in "older hands" who are gradually leaving the business. It is becoming increasingly difficult to hire these skills. The application of computer-aided technology to pattern making will solve this problem and result in lower cost and improved quality of clothing patterns. In addition, design capabilities will be improved.

SUMMARY

The objective of this project was to develop the necessary hardware and software which would permit digitizing master clothing patterns and then produce the patterns on numerically controlled equipment. This project will support approximately 200 clothing items requiring the preparation of 1900-2000 sets of pattern.

Contracts were awarded to Hughes Aircraft Corporation to deliver and install a computer pattern grading system capable of digitizing, grading, and producing master patterns. The system includes a terminal for input/output, a mini computer, disc drive, magnetic tape unit, and digitizing borad; see Figure 1, next page.

US Army clothing design, grading, and alternation data was fed into the system and master patterns were created.

BENEFITS

Instituting a pattern processing system greatly improved NARADCOM's design capability, reduced the cost of pattern fabrication, improved pattern storage and recall, established a standard pattern design, and improved the quality of Government master patterns.

Figure 1 - Computer-Aided Pattern Fabrication System

IMPLEMENTATION

The computer system has been successfully operated in a production mode since January 1976. In addition to supporting US DOD clothing procurements, the system is being used to support Saudi Arabian requirements.

MORE INFORMATION

Additional information concerning this project may be obtained from Mr. Leonard Campbell, US Army Natick Research and Development Command, AV 955-2347 or Commercial (617) 653-1000 ext. 2347.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project M75 9000 titled "MMT Improved Parts Programming for Numerically Controlled Machines" was completed in July 1976 at a cost of $7,500. The Intern Training Center at Red River Army Depot conducted this program for the US Army Materials and Mechanics Research Center.

BACKGROUND

An assessment of the state-of-the-art in numerical control (NC) part programming was needed. Ongoing efforts and recent accomplishments needed to be assessed in order to identify areas of duplication and areas of improvement for Army part programming. Parts programming for numerically controlled machine tools is constrained by a lack of standardization in NC program languages. A dissimilarity of functions and tooling exists between different manufacturers of the same equipment and between models of the same equipment from the same manufacturer. These problems are compounded by the proliferation of languages and machine tool models. Prior effort included an evaluation on milling applications entitled "Numerical Control Language Evaluation", Report Control Symbol OSD-1366, dated March 1974 prepared by Numerical Control Society.

SUMMARY

An analysis of the status of Numerical Control part programming was accomplished. A review of numerical control (NC) program languages and a review of functions and tooling of present NC machine tools was done as part of this analysis.

The Department of Industrial Engineering of Texas A&M University performed a literature search and conducted interviews to determine the current state-of-the-art of NC Manufacturing Technology, with emphasis on standardization of tooling and software. Based on the January 1974 to March 1976 literature search, there was little research on tool standardization. Software standardization problems reviewed included languages and post processors.

A report was published with limited distribution.

BENEFITS

A survey of the state-of-the-art in part programming for numerically controlled machine tools was performed. A technical report was furnished to the US Army Industrial Base Engineering Activity and US Army Materials and Mechanics Research Center.

IMPLEMENTATION

The results of this survey are available for review. The effort did not produce any recommended course of action.

MORE INFORMATION

Additional information concerning the project results may be obtained from Mr. Steve McGlone, US Army Industrial Base Engineering Activity, ATTN: DRXIB-MT, Rock Island, IL 61299, AV 793-6172 or Commercial (309) 794-3682.

Reference is made to technical report entitled, "State-of-the-art in Improved Parts Programming for Numerically Controlled Machines" dated June 1976. Prepared by Donald L. Allen, Dr. M.J. Fox, Jr., and Dr. R.E. Goforth (Texas A&M University).

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

Manufacturing Methods and Technology project 175 8162 titled, "Feasibility of Modifying N/C Language for the Automated Tape Layup System (ATLAS) (CAM Related)", was completed by the US Army Aviation Systems Command in June 1977 at a cost of $86,000.

BACKGROUND

The development of the concept of building helicopter rotor blades from composites resulted in the need for automating laborious hand methods for constructing blade components. The US Army Aviation Systems Command completed a contract with Goldsworthy Engineering, Inc. which resulted in the installation at a Boeing-Vertol facility of an Automated Tape Layup System (ATLAS). This prior effort cost approximately $2.3 million and is documented in technical reports AD A037447 and AD 021670.

The ATLAS is a five axis numerically controlled machine and manual methods or digitizing were used to pre-program control information. Existing methods of pre-programming are time consuming and susceptible to human error due to manual handling and the large amount of data generated. This project was undertaken to investigate the feasibility of pre-programming the ATLAS using automated methods. The automated methods for pre-programming would minimize or eliminate manual effort and reduce the leadtime required for numerical control tape preparation.

SUMMARY

The project was to assess the feasibility of tailoring software programs for specific tape layup applications proposed for automatic tape layup systems. The project was to develop specifications either for a general purpose numerical control (N/C) language or a modified existing general purpose language.

The work accomplished was broken out into six phases. Phase I involved the inspection of the ATLAS machine and a data gathering discussion with Boeing-Vertol personnel, the users of ATLAS. Phase II determined the requirements for system development. Phase III determined basic design of software to automate the production of the N/C control tapes. Phase IV performed software development and demonstrated automated NC tape preparation. Phase V performed economic and technical analysis. Phase VI published a final report.

The information gathered from discussions with Boeing-Vertol personnel was used for detailed system assessment and resulted in the selection of the root loop specimen (for the Ch-47C spar, helicopter component) as the demonstration article for comparison tests.

The system requirements were identified for (1) language development, (2) interface requirements to control the system, (3) the system's functions available for automatic control, and (4) the proper format of design data for input to the machine's software system.

The design of the computer software system was detailed according to three major functions: (1) Analysis - modules to aid in the analysis of existing and subsequently generated ATLAS control tapes, (2) Synthesis - module that generates ATLAS control tapes, and (3) System Support - utilizing routines that support analysis and synthesis.

The bulk of the program modules were written in Fortran IV for a Digital Equipment Corporation PDP-11/45 minicomputer. As shown in Figure 1, the three functions of this system are provided by five main programs.

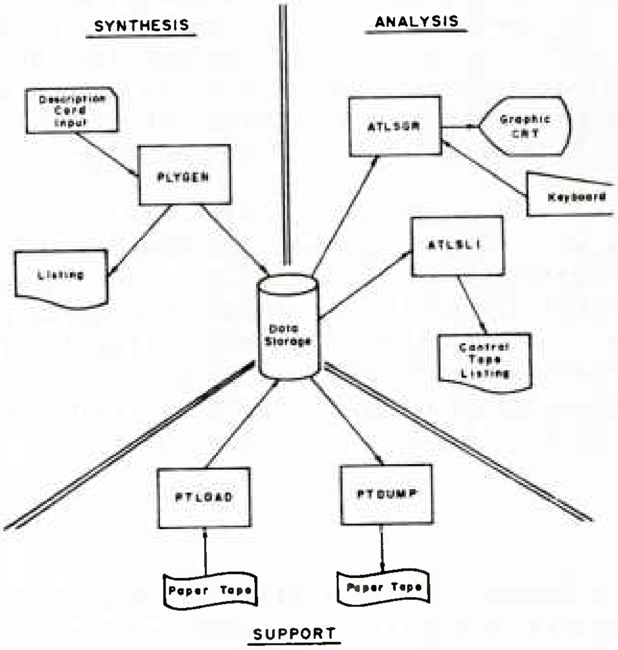

Figure 1 - ATLAS Programming System

The ATLAS machine was developed as a test model to determine the production equipment requirements for components made using an automated tape layup system. The interactive software system demonstrated pre-programming capability for root loop type components. Additional software development was identified for more complex parts, involving contoured or sculptured surfaces.

A successful demonstration during August 1976 showed that it was possible to pre-program an automated tape layup system using an interactive software system.

BENEFITS

The number of manhours of direct labor can be reduced for the preparation of control types for the ATLAS, including graphical checkout and listing examination. The cycle time for preparation of a control tape is considerably shorter using the interactive software system than using manual or digitizing methods. Additional savings may be realized by avoiding set up and teardown of tooling for tape preparation through digitizing and by keeping the ATLAS more available for production work.

IMPLEMENTATION

It is now possible to pre-program control information for ATLAS on "root loop" type components. The general requirements for an interactive software system have been identifed for pre-programming ATLAS control information for "root loop" type components and other components (e.g. multiply curved surfaces described as sculptured surfaces). However, there has been no direct implementation of this interactive software system into the production of Army materiel.

This software system project was a companion project to the ATLAS hardware effort. Based on the results of the five axis ATLAS hardware development demonstration, Boeing was able to design and build a three axis machine. This three axis machine does not require the sophisticated software system developed under this project. Therefore, the results of this project were not directly implemented due to a change in machinery requirements.

MORE INFORMATION

Additional information is available on this project in a technical report entitled, "Manufacturing Methods Report Feasibility of Pre-Programming for ATLAS", dated September 1976, DDC No. AD A037681. Authors are Robert N. Little and Charles E. Wells. The project officer is Mr. Daniel P. Haugan, US Army Aviation Research and Development Command, ATTN: DRDAV-EXT, 12th & Spruce Streets, St. Louis, MO 63166. AV 693-1625 or Commercial (314) 263-1625.

Summary Report was prepared by the Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 272 9641 titled, "Development of Interface Between CAD and CAM for Communications and Electronics Packages", was completed by the US Army Electronics Command in January 1975 at a cost of $200,000.

BACKGROUND

Integration of several computer controlled systems was needed to reduce the number of manhours of direct labor. The integrated system would design and fabricate electronic and communications devices and components at the US Army Electronics Command (ECOM). Manual drafting of engineering drawings and master patterns for distributed parameter printed circuit devices and similar drawings is time consuming and error prone.

Manual APT type programming of Numerical Control (NC) tapes is also time consuming and error prone. In prior efforts, the Electronics Command had acquired a stand alone interactive graphics system, an automated drafting/digitizing system, various Numerical Control (NC) machine tools, and terminal access to large computer systems.

SUMMARY

The objective of this project was to implement techniques which would link Computer Aided Design (CAD) and Computer Aided Manufacture (CAM). These techniques would be used in the design, development and fabrication of distributed parameter microwave devices (DPMWD) and multilayer printed circuit boards (MLPC).

Interface computer programs were written and a papertape connection was made to link an automatic drafting/digitizing system to a stand alone interactive graphics system. A computer program was written that enabled the system operator to automatically program NC tapes for various NC machine tools with either circular or linear interpolation. A NC printed circuit board drill and a chemical milling facility were procured. The effectiveness of the link between CAD and CAM was demonstrated by the design and fabrication of engineering samples and associated NC documentation, using the ECOM integrated system. Engineering samples, which were designed and fabricated consisted of:

(1) side coupled filter assembly
(2) multichannel filters
(3) artwork for microwave traveling wave tube, spiral cathode
(4) artwork for the master pattern of a distributed parameter device

See Figure 1 for the artwork of the master layer 1 for a distributed parameter printed circuit device.

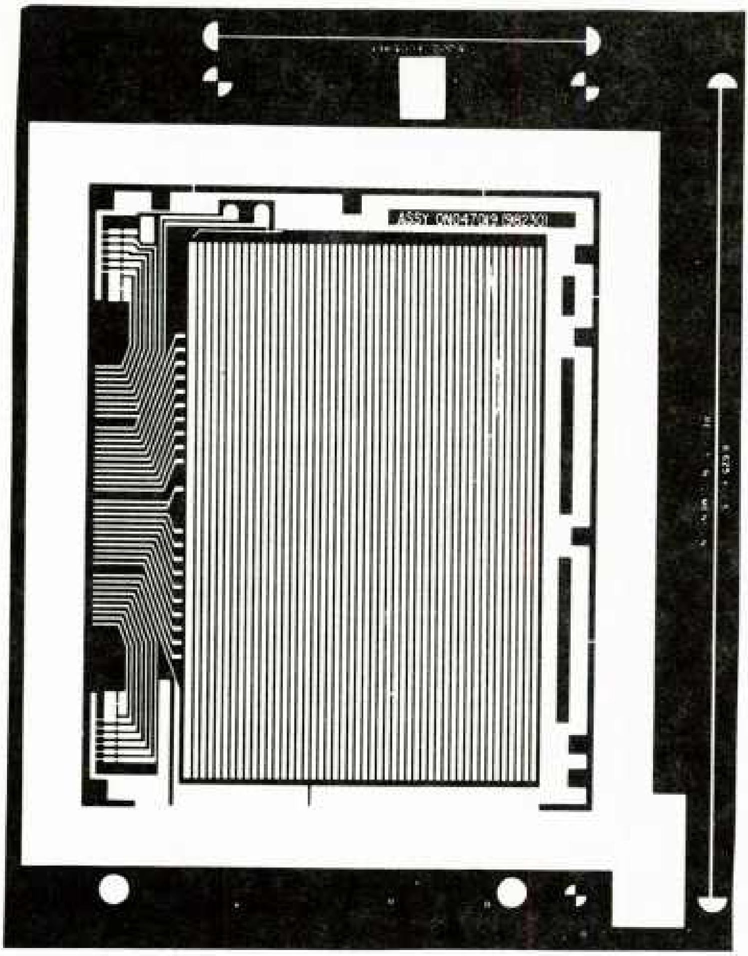

Figure 1 - Artwork Master Layer 1

Filters were designed and fabricated using the integrated system at ECOM, and returned to the design engineer in one half day. Thus, the engineer was able to produce a design, have it fabricated and returned for testing in a single day. In addition, the artwork and NC tapes were verified and available as part of the technical data package for competitive procurements.

BENEFITS

The ECOM integrated system did result in a reduction of cost (direct labor hours) and of lead time for the design and fabrication of prototype devices and components at ECOM.

IMPLEMENTATION

The results of this project were implemented for a short period of time at ECOM, Ft. Monmouth, NJ for the fabrication of prototypes. However, due to a reorganization and technology advances, this equipment is now used for other purposes. Therefore, this technically successful effort was not implemented as planned because of a change in organization requirements.

MORE INFORMATION

Additional information is available on this project in a technical report titled "Development of Interface Between CAD and CAM", dated May 1975, DDC# AD A009491, Author David K. Ruppe. The project officer for this effort is Mr. David K. Ruppe, US Army Communications Research and Development Command, ATTN: DRDCO-AM, Fort Monmouth, NJ 07703, AV 995-4215 or Commercial (201) 544-4251.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project T75 4561 titled, "Computer Aided Die Design and Computer Aided Manufacturing for Forging of Track Shoes and Links" was completed by the US Army Tank-Automotive Research and Development Command in January 1977 at a cost of $135,000.

BACKGROUND

Army tracked vehicles use a large number of track shoes and links. These items are made from various steel alloys by closed die forgings, followed by finish machining. A considerable portion of their manufacturing cost is incurred in producing the die sets used during forging. Excessive die wear and unexpected breakage often add to these expenses.

Proper design of forging dies is not only costly but is highly dependent on the skill and experience of designers. Procedures utilized are lengthy and inexact, and at best provide many opportunities for human error.

SUMMARY

A computerized system for designing and manufacturing track shoe dies for military vehicles was developed. This system, known as "TRACKS", is a totally interactive system that greatly assists die designers.

Figure 1 outlines the TRACKS system. The designer initiates the process by feeding the computer a file of coordinates describing each cross section of the forging. The computer then calculates the geometric properties of each section and performs stress analysis calculating and displaying stress distribution curves and metal flow surfaces.

TRACKS also has a preform design option which allows the designer to make modification to the preform. The designer is able to visualize how the preform will physically fit the finished die just before the finished impression is made.

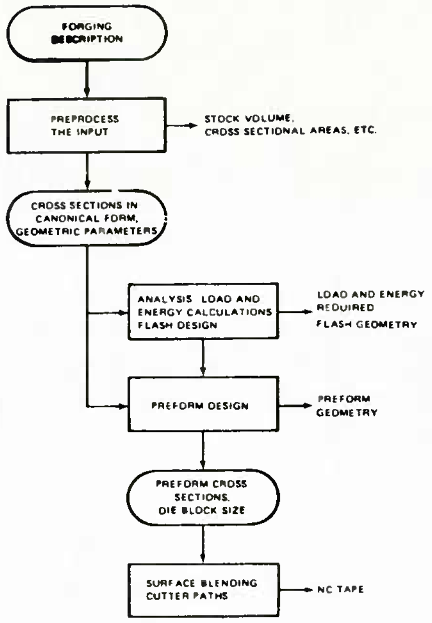

Figure 1 - A procedural outline of the TRACK system.

Once the designer is satisfied and load analysis and preform design have been completed for all sections, the CAM phase of TRACKS is used to prepare a tape for NC machining of a model or an EDM electrode of the preform.

BENEFITS

Application of CADCAM techniques to the design and manufacture of forging dies can greatly enhance the process and improve the productivity of die designers. Implementation of TRACKS allows the designer to evaluate a number of design alternatives in a fraction of the time previously required leading to improved dies at a reduced cost.

IMPLEMENTATION

This system of computer programs is very flexible and can be applied to a variety of other forgings with similar geometric configurations. The system is being well accepted by the forging industry.

MORE INFORMATION

This system is available to any interested US company. A final report and a 12-minute 16mm film are available. Contact Mr. Tom Wassel, US Army Tank-Automotive Research and Development Command, AV 273-1814 or Commercial (313) 573-1814 for additional information.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 573 1239 titled, "Application of Automatic Drafting and Digitizing Equipment to Manufacturing Use" was completed by the US Army Armament Command in September 1974 at a total cost of $60,000.

BACKGROUND

The project was undertaken to evaluate the potential applications of automatic drafting and digitizing. Design of tools and fixtures and the preparation of Numerical Control (NC) tapes for lathes and two axis mills were included in this evaluation. Previous methods used for the design of mechanical components and the associated NC tape preparation were manual, labor intensive, and error prone. Prior to this project, NC tapes were prepared at Edgewood Arsenal with computer assistance; however, Automatic Programmed Tool (APT) or similar types of programming necessitated batch processing on a large computer system. The manual preparation of input cards and scheduling for computer time resulted in delays. Prior effort funded the purchase and prove out of automated drafting and digitizing equipment for $250K.

SUMMARY

The main objective of this project was to adapt equipment to the preparation of NC tapes for lathes and two axis milling machines. During the span of this project a number of piece parts (primarily artillery shell components) were fabricated utilizing NC tapes generated by the Automatic Drafting and Digitizing System. The available software permitted the preparation of NC tapes for those machines where post processors were on file. If new machine tools were procured, then new post processors were usually needed, depending on type of machine tool and controller. Data were generated to compare the speed and accuracy of NC tape preparation with the manual APT type programming on large computers and with the Automatic Drafting and Digitizing System.

The Automatic Drafting and Digitizing System produced NC tapes faster and more accurately than previous methods. The laborious task of manually inputting large quantities of data was minimized and NC tapes could be verified in two dimensions in several views prior to machining. Figure 1 is a block diagram illustrating the system software and functions.

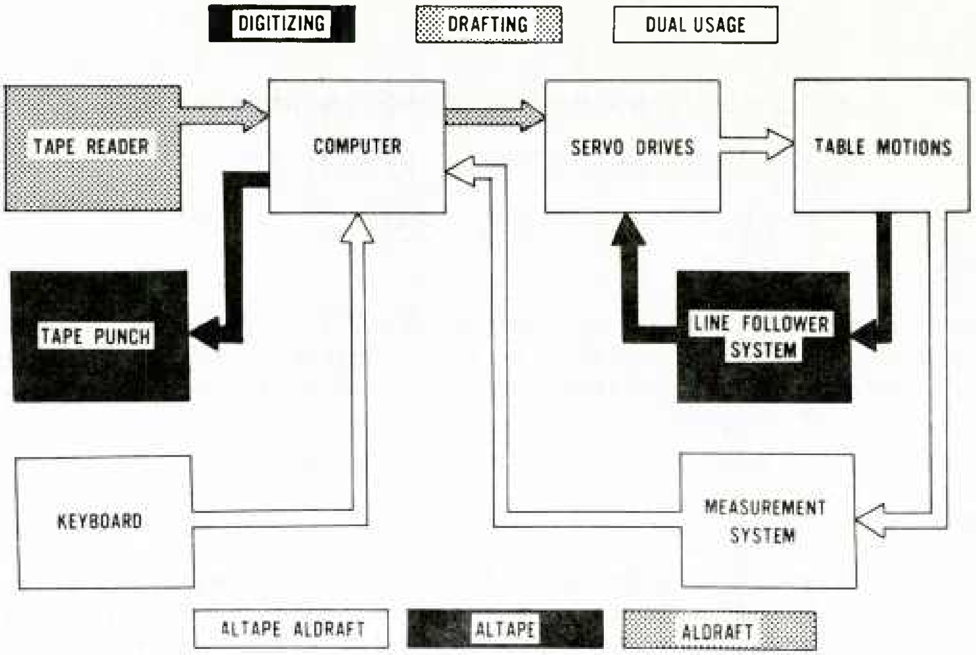

Figure 1 - Altape/Aldraft Block Diagram

BENEFITS

The primary benefit derived from this project was the expertise developed in the area of computer aided preparation of NC tapes through a stand alone minicomputer based drafting and digitizing system. A reduction in the number of manhours of direct labor was realized for the preparation of NC tapes for lathes and two axis mills using automatic drafting and digitizing system in lieu of manual APT type programming.

IMPLEMENTATION

The results of this technically successful effort have not been implemented and are not currently planned for implementation. A change in the mission/function of the Edgewood Arsenal resulted in a removal of most of the numerical control machine tools. The NC tape preparation is not mission essential at the newly formed US Army Armament Research and Development Command, Chemical Systems Laboratory, Edgewood, MD. However, the automatic drafting and digitizing system is being used to generate drawings, flow charts, milestones, charts, pert charts, and some mechanical design. The expertise obtained from this project and related efforts is being used for generation of requirements for a "paperless" technical data configuration management system.

MORE INFORMATION

Additional information is available on this project in a technical report titled, "Application in Computer Aided Design and Numerical Control Manufacturing Using Automated Drafting and Digitizing", dated January 1977, AD 755502, Author-Vernon Pearle.

The project officer is Mr. Vincent Scheno, US Army Armament Research and Development Command, ATTN: DRDAR-TSC, Aberdeen Proving Ground, MD, 21010, AV 584-3308 or Commercial (301) 671-3307.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 672 6779 titled, "Optimization of Machining Parameters for Numerically Controlled and Conventional Machining" was completed by the US Army Armament Command in July 1974 at a cost of $85,000.

BACKGROUND

A system was needed to aid in "tuning" the machining conditions for single-operation and multiple-operation (numerically controlled) machine tools. Machining parameters were being selected by empirical (or arbitrary) methods with little feedback for improvement or control on performance. Manual selection of machining parameters is skill dependent and not always reliable.

As a result of prior efforts, two computer programs were developed and tested. A machining performance index program based on Taylor's tool life equation, and a production optimization (PIM) program based on machining data and cost. A final report is available on prior efforts, DDC #AD 754569.

SUMMARY

A system for optimizing machining conditions for single-operation and multiple-operation machine tools was developed and partially implemented at Rock Island Arsenal. The measures of productivity considered were: (1) Production cost per piece, and (2) Production rate.

Computer programs were updated and a new program was developed. Simulation runs were conducted to debug these programs and develop procedures for collection of machining data. The new program developed was the Machining Optimization (MACHOP) program.

Data was collected during the actual production of a product which was to be shipped to a customer. The data collection was frequently conducted over an extended time period. Because of the difficulty in collecting data for the PIM program and in using the program with shop data, the MACHOP program was developed. To simplify collections of data in the shop, observations were usually taken in cycles; for example, a set of four observations at two adjacent feeds and two adjacent speeds.

The results were submitted to the MACHOP program and two performance indices were calculated (cost/piece, production rate). Evolutionary operation analysis and a response surface regression analysis were performed on these indices. The MACHOP program was verified using an analysis of a turning operation on a Monarch Lathe with a recoil cylinder (4140 steel). The data sample was collected in 14 days over a period of two months in which 188 parts were machined using 296 tool edges. This program makes possible the choosing of optimum machining parameters such as cutting speeds and feeds with respect to time and costs.

In application, two variables of the machining parameters may be adjusted independently or simultaneously using small step increments. Computation of results from data collected were provided as printouts. These printouts show time and cost performance at the machining parameters from which the data used for computation has just been taken. These printouts forecast settings which could improve performance. Machining at adjoining machining parameters was tested and analyzed until the printouts repeatedly indicate that the optimal conditions had been reached.

BENEFITS

All Army items presently machined, such as gun barrels and recoil cylinders can benefit through increased production rates and/or reduced machining costs. Items made by numerically-controlled turning and boring can particularly benefit as the optimization program is oriented toward control of all numerically-controlled machining operations.

IMPLEMENTATION

Implementation is not yet realized since a current MMT effort, 680 7707 titled "Automated Process Control for Machining (CAM)" must be completed. However, the results of this project were used to establish the "Economics in Machining" section of the Machining Data Handbook and to introduce the concepts of "Optimized Cutting Speed Equation" and "Optimized Tool Life Equations".

MORE INFORMATION

Additional information concerning the project results may be obtained from Mr. Ray Kirschbaum, SARRI-ENM, Rock Island Arsenal, Rock Island, IL 61299, AV 793-5363 or Commercial (309) 794-5363.

Additional reference can be made to technical report AD A018124, titled "Development and Adaptation of a Control System for Optimization of Single and Multiple Operation Machining" dated July 1974. Prepared by Mr. John S. Ramberg (Intertech Corp).

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 675 7111 titled, "Computer Assisted Graphical Techniques for Production of Weapon Systems" was completed by US Army Armament Research and Development Command in June 1977 at a cost of $120,000.

BACKGROUND

The number of manhours of direct labor needed to generate numerical control tapes with manual Automatic Programmed Tool (APT) programming can be excessive, depending on component and machine tool. In addition, the number of manhours of direct labor for manual drafting and manual or semi-automatic maintenance of a document management system can also be excessive.

The project was undertaken to implement a stand alone interactive graphics system at Rock Island Arsenal, Illinois. This system was planned to have a numerical control tape preparation capability, and this system was planned to aid the design, analysis, documentation, and manufacturing phases of weapon system components.

Prior efforts consisted of the identification and procurement of an interactive computer graphics hardware and software. The prior effort consisted of a refresh graphics system with minicomputer and plotter, and software package.

SUMMARY

An objective of the project was to establish interactive graphical techniques which would enable a reduction in production engineering lead times needed for the design of special tools, fixtures, dies, and cast patterns. A second objective was to compare numerical control tape preparation times using manual APT type programming and computer assisted graphical part programming.

The greatest amount of time and effort on this program was spent in getting the software and hardware in operational condition. It included work on the minicomputer hardware and the refresh graphics system, as well as the companion software. Some weapon system design work was done using the analysis, documentation, and mechanical design features of this system. See Figure 1 for photograph of this system.

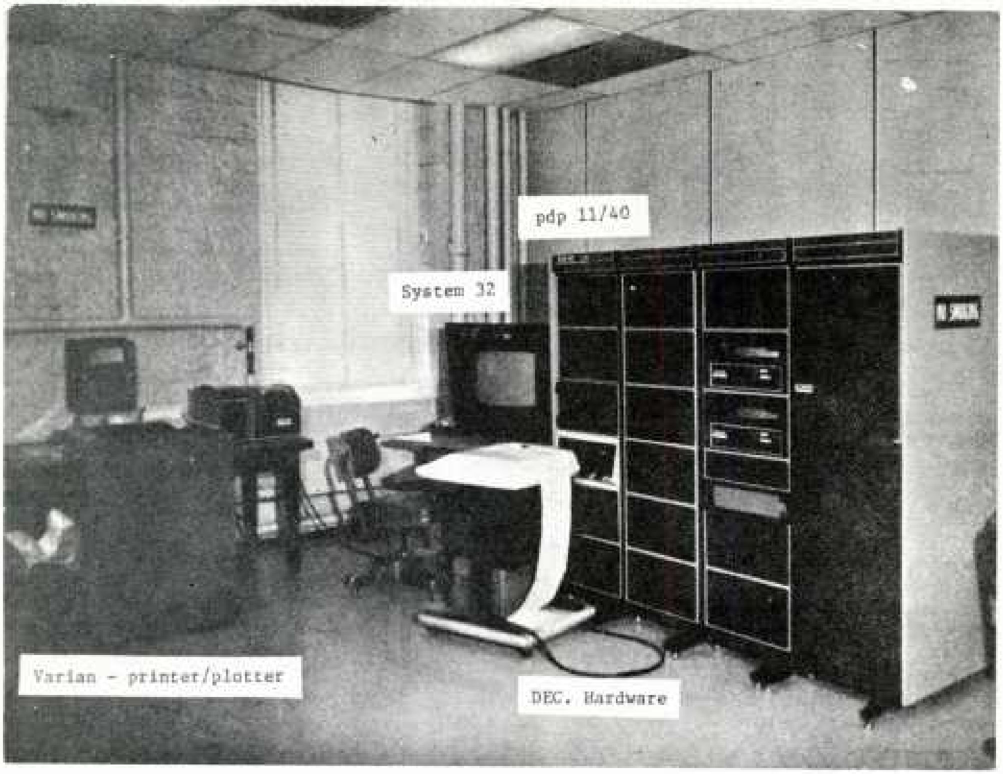

Figure 1 - Hardware for the interactive
graphics system.

Two "Benchmark" components were chosen to test the numerical control (NC) tape preparation capability of this system. One component was relatively simple in design and machining, the other component was considered complex in design and machining. The simple component used two axis contouring, with positioning along a third axis. A comparison test for the simple component was made on the time required to prepare a functional NC tape with the Interactive Graphics system and the time required to prepare a functional NC tape by manual APT programming. A similar comparison was tried for the complex component.

A time study was conducted during the programming and machining of the components. For the simple component, the total time used by the manual APT method was 23-1/2 hours as compared to 9 hours with the Interactive Graphics method. The complex component and other components of similar complexity proved to be impossible to design on the graphics screen, due to the limited capability of the software. Shortcomings of this interactive refresh graphics system were: (a) the excessive and annoying flickering of the screen, (b) slowness in reproducing an image on the screen, and (c) limited design capability.

BENEFITS

A reduction in the number of direct labor hours for the preparation of some NC tapes can be realized by using this interactive graphics system.

IMPLEMENTATION

This project was not technically successful and the results have not been implemented. However, the interactive graphics systems has been moved to Watervliet Arsenal (WVA) and is providing service as a finite element mesh generator and design analysis tool with WVA designed software. The contractor supplied software is still not functioning adequately. WVA has tentative plans to modify and implement the supplied software for design documentation and NC tape preparation.

MORE INFORMATION

To obtain additional information on the equipment, contact Mr. James Pascale, Benet Weapons Lab, DRDAR-LCB, Watervliet Arsenal, Watervliet, NY 12189, AV 974-5706 or Commercial (518) 266-5706.

To obtain additional information on the project, contact Mr. Bjorn L. Hofgaard, US Army Armament Research and Development Command, DRDAR-LC, Dover, NJ 07801, AV 880-4343 or Commercial (201) 328-4343.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

ELECTRONICS

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 274 9535 titled, "Manufacturing Methods for the Production of a Four Stage Thermoelectric Cooler" was completed by the US Army Electronics R&D Command in March 1976 at a cost of $220,000.

BACKGROUND

This project established the production techniques, manufacturing processes, and a pilot line for the fabrication of a reliable low-power thermoelectric cooler. This cooler was to be capable of cooling infrared detector arrays to temperatures of 193°K (-80°C) or colder. Thermoelectric cooling is the result produced by absorbed thermal energy and occurs when an electric current undergoes energy level changes upon passing from a low to a high energy carrier (Peltier effect).

Grouping several P and N type semiconductor pairs or couples enhances this absorption or cooling effect, and was the method used to achieve the project objectives.

SUMMARY

Marlow Industries, Inc., established the rates, yields, tolerances, special fixtures and the measuring equipment required to fabricate 50 thermoelectric coolers per month which would meet the required performance specifications.

The thermoelectric cooler is a series of thermoelectric couples arranged into four parallel-coupled thermally conducting stages, with a rigid mechanical structure used for support. Figure 1 shows a typical cooler.

The work performed included the following manufacturing techniques and processes:

a. Element fabrication - A diamond impregnated slicing wheel performed vibration free slicing of the brittle thermoelectric P or N material ingots into wafers. A gang saw, consisting of 13 each diamond edged cutting wheels, diced the wafers into elements. Before dicing, the wafers were nickel plated to inhibit susceptibility to doping by external materials. This coating proved adequate to eliminate pretinning the P or N elements prior to reflow solder bonding to the ceramic/tab assembly. Previously, these operations, including element pretinning

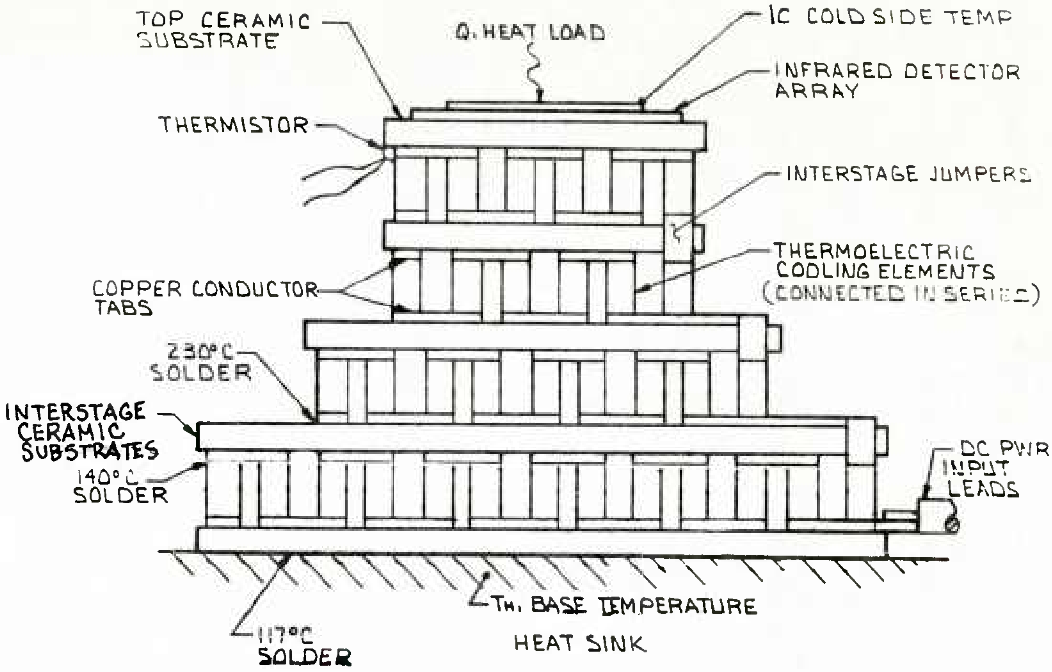

Figure 1 - Four Stage Thermoelectric Cooler

consumed about a third of an operator's time. Now the processes take less than 1% of the operator's time.

b. Ceramic/tab assembly - Copper conductor pads (tabs) were reflow soldered onto printed moly-manganese pattern ceramic substrates. After the tab attachment, the assembly was nickel plated to provide a complete diffusion barrier coating. Originally, berylia ceramic substrates with full-faced metallization on both sides were used. The circuit pattern was made in the metallization by scribing the surface with an outer diameter mounted blade saw. A low 60% yield of completed assemblies was obtained via this scribing method. Silk screen printing the metallization in finished circuit patterns raised the overall yield for this assembly to approximately 85%.

c. Element assembly and stage stacking - The P and N thermoelectric elements (bars) were positioned onto the ceramic/tab assembly conductor pads and reflow solder bonded. A silicon rubber type lattice fixture was devised to align the elements in place prior to bonding. Very few rejects from solder shorts or voids occurred since the heights of the elements were closely controlled. Also, since the element bonds can be reheated, most defects at this operation could be repaired. Yield approached 100%.

The completed first stage (bottom stage) was mounted and reflow soldered to the second stage, etc. until the four stage fabrication was completed. The cooler assembly contains a total of 216 thermoelectric elements composed of 128, 54, 22 and 12 elements per stage.

d. Testing - The coolers were evaluated by testing in a vacuum test stand which was enlarged to contain and test six coolers at once. Test data verified that the coolers achieved $193^{o}K$ or colder with a power input of approximately 6 watts and a heat load equivalent to an infrared detector array.

BENEFITS

Reduction in cooler cost will occur due to the use of assembly jigs and fixtures in lieu of hand fittings, the use of production techniques in place of shop methods, the reduction of assembly time, an increase in yield, and a shift from engineering types to normal production personnel. Due to this MMT, the unit cost was reduced more than 50%, from $520 to $220 per unit.

IMPLEMENTATION

The four stage thermoelectric cooler is now available as a production item. The cooler is used with the hand held viewer, AN/PAS-7. It is ideal for infantry use since it is lightweight and is an electronic assembly with no moving parts.

MORE INFORMATION

Additional details may be obtained from Mr. Richard Buist or Mr. Raymond Marlow, Marlow Industries, Inc., Garland, TX, AC (214) 494-2521. The contract was DAAB05-74-C-2526.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 276 9732 titled "MMT Fabrication and Attachment of Heat Pipes to Thyristor Wafers" was completed by the US Army Mobility Equipment Research and Development Command in December 1978 at a cost of $346,000.

BACKGROUND

Prior to this project, only prototype processes existed for fabricating high current, solid state thyristors with integral high pipes. Transcalent (high power) thyristors utilize heat pipes which are directly bonded to the silicon wafer to eliminate the mechanical interfaces between the wafer and the integral cooling fins.

Reduced thermal impedance results in an increased average fin temperature and a marked reduction in size and weight compared with conventional rectifier/heat sink assembles, see Figure 1.

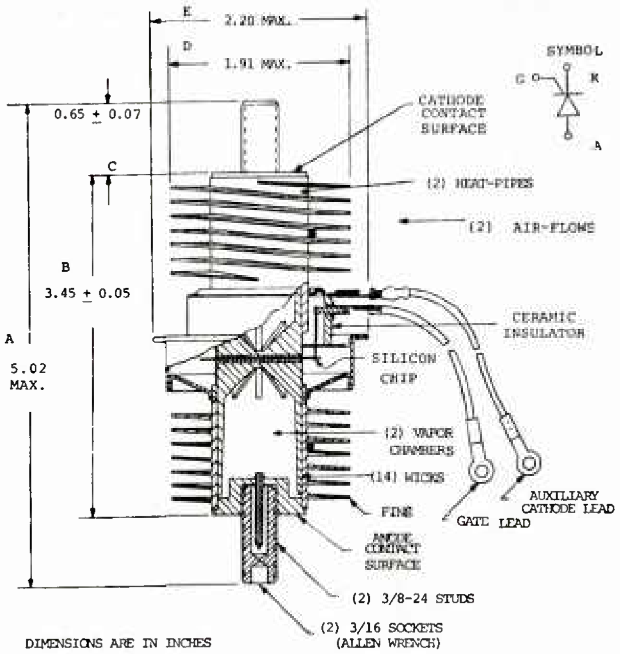

Figure 1 - Transcalent SCR Thyristor-Cross Section Drawing

SUMMARY

RCA Corp. SSD-Electro Optics and Devices Division established manufacturing processes and control procedures including development of jigs, fixtures and production test equipment for producing low cost, reliable transcalent thyristors.

New heat dissipation techniques, which include use of a wick structure, were used to reduce the thermal impedance of the thyristor thereby lowering the temperature of the silicon chip.

The work performed was divided according to subassembly as shown in Figure 2, and the processes were optimized.

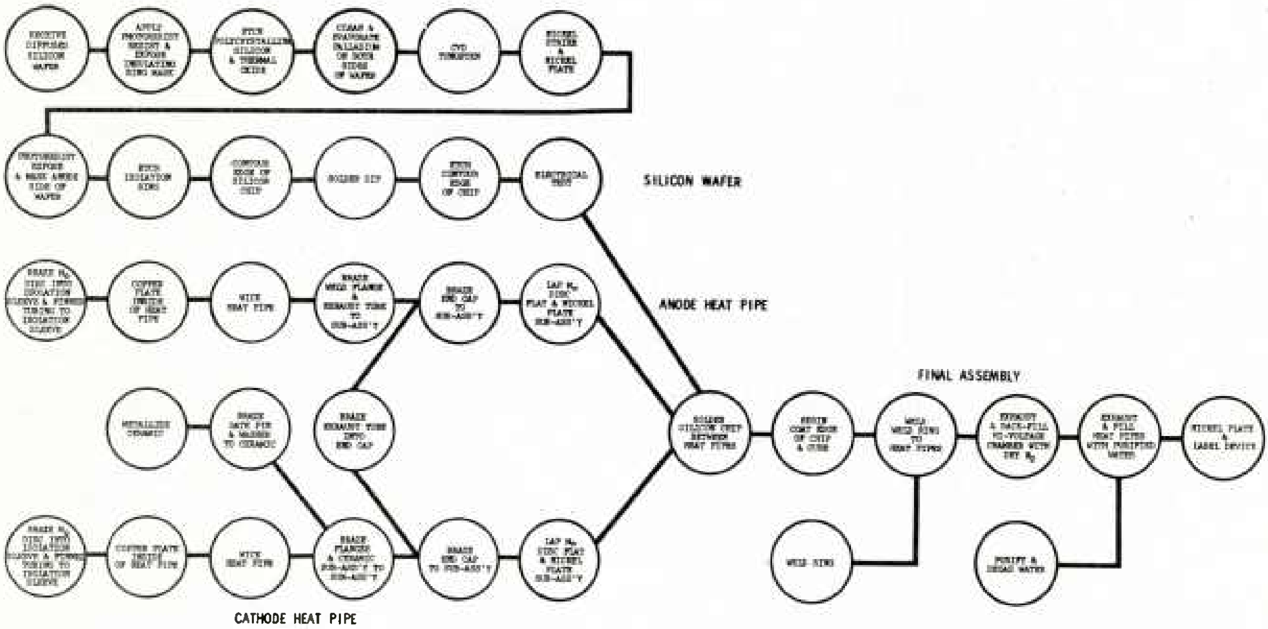

Figure 2 - Flow Chart of Process Steps

a. Silicon Wafer - Hydrogen furnace soldering was used to attach the silicon wafer to the heat pipes to insure uniform solder wetting and freedom from voids. Prior to heat pipe attachment, the silicon chips were metalized by Chemical Vapor Deposition (CVD) of tungsten. Preparation for metalization included vapor etching, cleaning, and vacuum evaporation of palladium onto both sides of the silicon wafer.

b. Heat Pipes - Improvements included brazing molybdenum discs to the ends of the anode and cathode heat pipes to eliminate the need for a vacuum joint to the silicon chip. Blisters and pits adjacent to this joint were eliminated by changing this section of the heat pipe to oxygen free high conductivity (OFHC) copper. Other work consisted of sintering copper powder to form wicks, brazing end caps, and machine lapping.

c. Final Assembly - Work performed included heliarc welding of the weld ring, vacuum exhausting, and baking and backfilling the center high voltage chamber with dry nitrogen gas. Pores in the wicks of the heat pipes were vacuum exhausted and filled with ultra pure water thru a three-way valve. Pinchoff was followed by final electrical test.

BENEFITS

Production capability for a lighter-weight smaller sized solid state thyristor is now available.

Due to the integral heat pipes (cooling fins), maintenance and logistic problems have been reduced. No specific cost saving was determined; however, integration of the heat pipes means improved reliability of the silicon wafer and therefore longer life of the thyristor itself.

Applications comprise any electronic circuit requiring high power silicon controlled rectifier requirements. These include phase control, power conditioning, and switching for traction motor driver, vehicle driver, and other high power applications.

IMPLEMENTATION

Transcalent thyristors are now available as production items from RCA SSD-Electro-Optics and Devices Division.

RCA has commercial rights for the units and is promoting the devices through catalogue sheets, articles in technical journals, and application seminars. Also, sample units are presently available on loan from MERADCOM for potential users to determine suitability in new or established Army end items.

MORE INFORMATION

Additional information may be obtained from Mr. Frederick G. Perkins at MERADCOM, Ft. Belvoir, VA, AV 354-5724 or Commercial (703) 664-5724. The contract was DAAB07-C-8120.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

INSPECTION AND TEST

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology projects R76 3138 and R77 3138 titled, "An Acoustical Holographic Passive Non destructive Testing Techniques for Ceramic Radoms" was completed by the US Army Missile Research and Development Command in August 1978 at a cost of $173,000.

BACKGROUND

The present non-destructive proof testing method used to inspect ceramic composite structures is not reliable or economical. Also, the proof-testing degrades the structural integrity of these structures which causes reduced mission reliability. The Acoustical Holographic Passive Non-destructive testing concept was selected for the ceramic composite structure inspection for two reasons; namely, the production of an acoustical interferometric fringe pattern does not require external loading, and the medical field has demonstrated the feasibility of the concept as it is used for exploratory diagnosis.

SUMMARY

The objective of this effort was to scale-up the medical field's holographic concept by incorporating higher power acoustics and better acoustic dampening. The results of this effort produced an Acoustical Real Time Holographic Image Reproduction System (ARTHIR), Figure 1, with sufficient power and damping characteristics for the nondestructive testing of ceramic composite structures. The features of this system include:

- Large diameter (approximately 4 inches) ultrasonic beam and corresponding area.
- High intensity ultrasonic beam
- Improved penetrability for thick test objects
- Excellent water tank damping characteristics
- The preliminary nondestructive testing measurements indicated that the system resolution approached the theoretical differation limit for the acoustical wavelength (in the water medium) of 0.3, 0.5, and 1.5 mm.

BENEFITS

The potential benefits to be realized from implementing the results of this effort are a reliable and cost effective ceramic radom real time automated nondestructive testing system and an improved product.

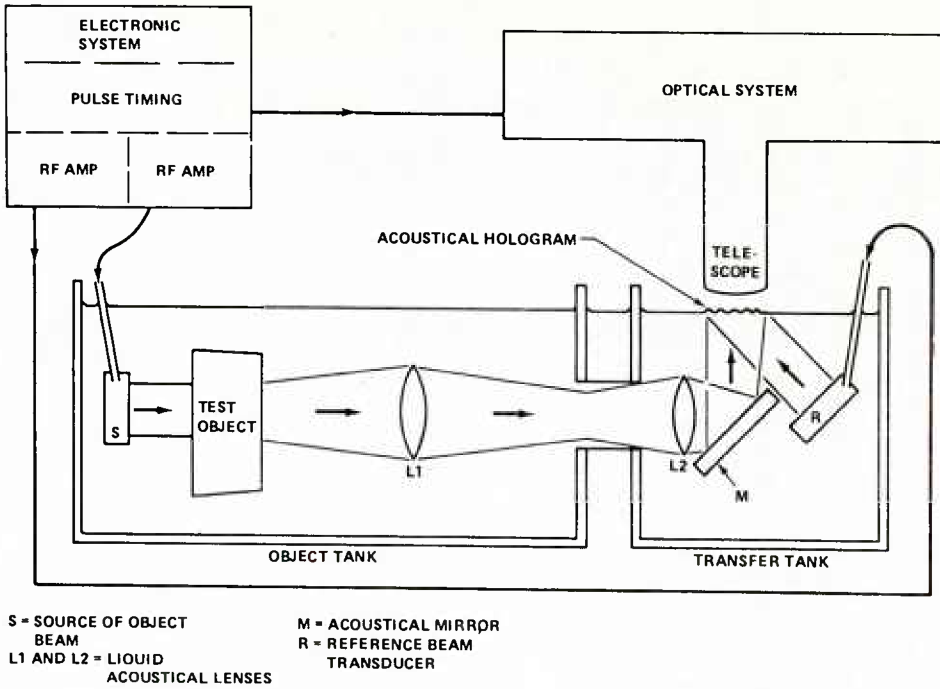

Figure 1 - ARTHIR System Schematic

IMPLEMENTATION

The Acoustical Real Time Holographic Image Reproduction System is available for implementation. The use of this system is being considered for inspecting the Pershing radom material, duroid. The final report is being widely distributed.

MORE INFORMATION

Additional information on this effort is available from Dr. Kenneth W. Suits, AV 746-5692 or Commercial (205) 876-5692. The project is reported in USA MIRADCOM Technical Report T-78-10, "Real Time Acoustical Holography System" October 1977.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 570 4139 titled "Application of Radar to Ballistic Acceptance Testing of Ammunition (ARBAT)" was completed by ARRADCOM in May 1977 at a cost of $328,000.

BACKGROUND

Lot acceptance and failure verification of small rockets and ammunition has been performed primarily by means of sight, sound, and in some cases, by high speed film. Data reduction and summarization by these means is laborious and as a result of the high cost, data was not always taken.

The purpose of this effort is to upgrade the ballistic testing of large caliber ammunition. Successful completion of this series of projects will provide a capability for the complete monitoring of the trajectory and certain performance characteristics of a fired round. The original scope of the effort was to modify existing equipment for this task but as the project developed the trend was towards a completely new self contained unit.

SUMMARY

A contract was awarded to MITRE Corporation to investigate the feasibility of a polystation system and to evaluate currently available radar techniques with respect to their ability to meet the Army requirements. A baseline design was also to be developed. As a result of the MITRE Study, the polystation system was rejected as unsuitable for proving ground use and several alternatives were proposed. A system using full electronic beam steering in elevation and a combination electronic and mechanical beam steering in an azimuth was selected. Based on the MITRE effort, ITT Gilfillan was contracted to provide an overall system design. The proposed system is an X Band, coherent pulse MTI System using a 10' X 12' planar antenna with a low side lobe pencil beam, a fast fourier transform doppler analyzer, a mini-computer, real time visual displays, and data recording equipment.

Specifications were prepared for a four bit diode phase shifter and Microwave Associate was contracted to manufacture the units. Figure 1 is a photograph of the ARBAT antenna. The phase shifters are mounted along the vertical edge of the antenna.

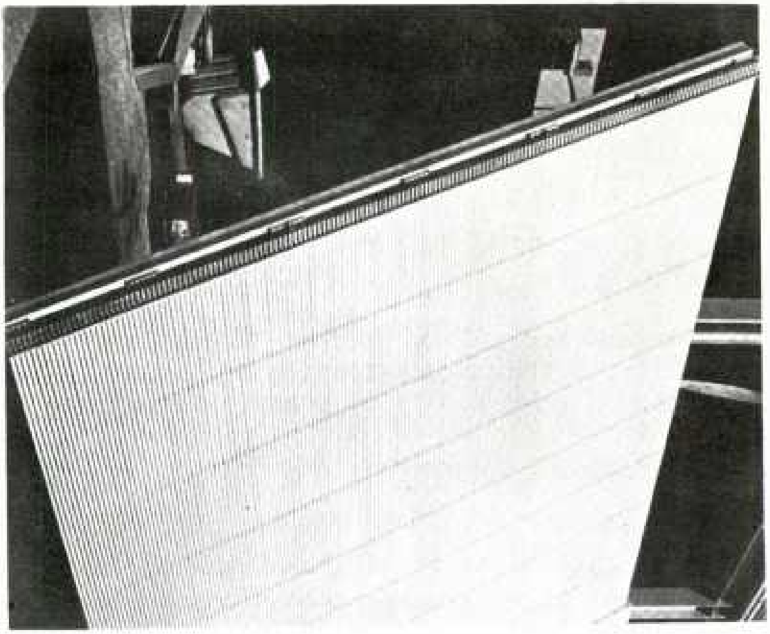

Figure 1 - ARBAT Antenna

BENEFITS

This individual project does not have a system as its end project. The stated benefits will accrue only after completion of the final project. The tasks consisted primarily of feasibility studies, preliminary system design and manufacture of phase shifters for a planar phased array antenna. The advantages of this antenna are to reduce the slewing problems associated with the parabolic antennas and to provide more detailed trajectory data. An ITT Gilfillan report referenced below contains the specifications for this antenna.

IMPLEMENTATION

The antenna that was provided is being used for the follow-on efforts that will develop a complete testing system. The ARBAT System is presently at Yuma Proving Grounds where it will undergo functional testing.

MORE INFORMATION

For additional information, contact Mr. O. Briedis, ARRADCOM, AV 880-5486. For Antenna details, see Report No. 5059B "Application of Radar to Ballistic Acceptance Testing of Ammunition (ARBAT), Phase B Antenna Development/Fabrication" dated 30 September 1976. Contract No. DAAA21-73-C-0664.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 574 4507 titled, "Application of Computer Aided Design to the Acceptance Testing of Production Piezoids" was completed by the US Army Armament Research and Development Command in February 1976 at a cost of $125,000.

BACKGROUND

Piezoceramic elements used on ordnance fuzing are purchased with a specification that requires determination of sensitivity constant by force loading methods at ambient temperature only. Although measurements are desirable at temperature extremes, it is difficult to provide repeatable force loading techniques inside a temperature-controlled chamber. Production orders are placed with vendors to supply a material with specific characteristics without being able to test for them. Preliminary work to model and simulate piezoids characteristics was accomplished under MT project 573 4507.

SUMMARY

The objective of this program was to establish acceptance criteria and testing of production piezoids to insure the items produced will perform their intended functions when assembled in an end item.

The major emphasis for this project consisted of extensive piezoid testing. Technical assistance was provided by a contractor and an in-house effort utilized test data to develop a computer model of the piezoid. The model included parameter variation as a function of force, temperature, and voltage.

In addition to modeling the piezoid, a model for simulating the entire piezoid power supply was derived. This model could predict piezoid parameter variation and the output voltage as a function of the acceleration profile of the round, ramweight, and shorting bar closure.

The results of this project has provided an analytical capability for predicting piezoid performance. The project demonstrated for the first time under controlled laboratory conditions the actual behavior of sample piezoids.

BENEFITS

The successful completion of this program will result in a basis for specifying piezoid characteristics based upon definition of the critical parameters, knowledge of their variation and enhanced analytical methods for simulating piezoid performance. The data collected during this project resulted in recommending the computer model be used to supplement production specifications.

IMPLEMENTATION

The results of this project were used in the follow-on FY75 effort.

MORE INFORMATION

Additional information on this project is available from Mr. J. Bianchi, ARRADCOM, Dover, NJ AV 880-3608 or (201) 328-3608.

Summary Report prepared by the Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 575 4507 titled, "Application of Computer Aided Design to the Acceptance Testing of Production Piezoids" was completed by the US Army Armament Research and Development Command in October 1976 at a cost of $130,000.

BACKGROUND

Piezoceramic elements are used extensively as the source of electric power supply for electronic fuzes in artillery projectiles. The relationship of the power supply unit to the other components of a particular type of projectile is illustrated in Figure 1. A cross-sectional schematic of a specific piezo-electric power supply identifing key components is provided in Figure 2. These "piezoids" are produced by vendors and procured by the Army in very large quantities. Reliance is placed on the vendor to supply elements with specific characteristics without subjecting them to production acceptance testing due to the difficulty in providing repeatable force loading techniques inside a temperature controlled chamber. Original work to arrive at methods of standardization and improved ways of specifying and accepting production parts was accomplished under FY73 and FY74 projects.

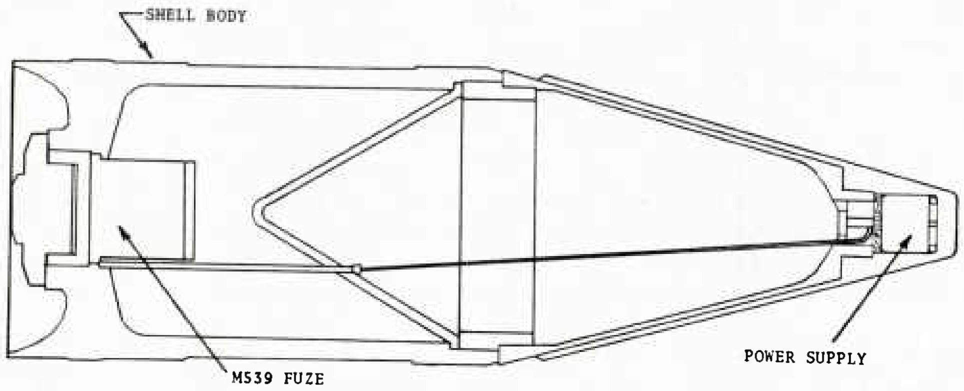

Figure 1 - Cross section of projectile showing the relationship of the power supply to the other components.

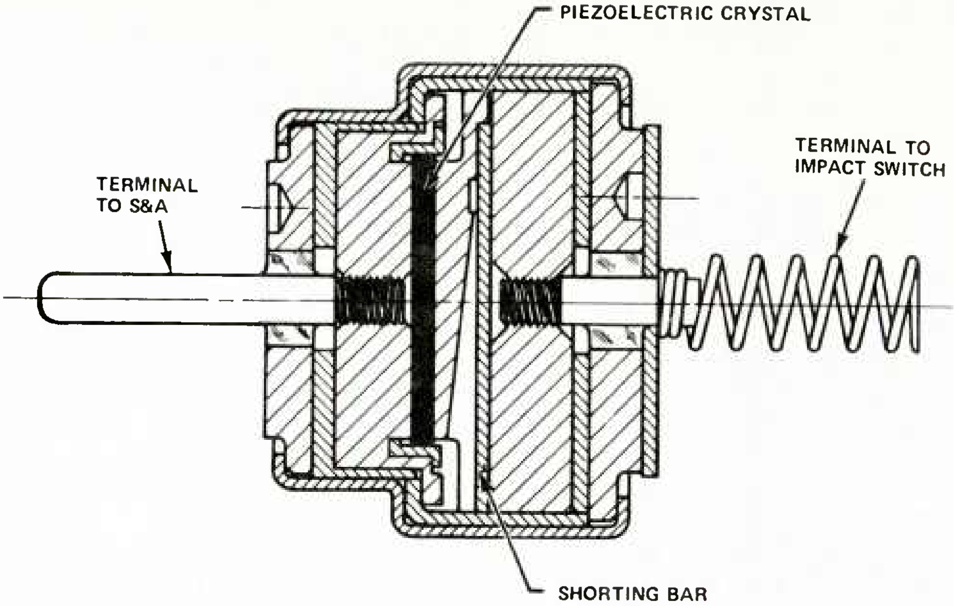

Figure 2 - A cross section of a piezo-electric power supply unit.

SUMMARY

The object of this program was to provide production acceptance criteria and testing of piezoids to insure that the items produced will perform their intended function when assembled in an end item.

The work performed in FY75 was a continuation of previous efforts. In FY75 the two major areas of concentration consisted of (a) further work in defining crystal parameters and testing, and (b) modeling of entire piezoid systems including utilization of the models for predicting system performance and aiding in malfunction investigations.

The first area was accomplished with the assistance of the Pennsylvania State University Materials Research Laboratory. Previous work was reviewed and a procedure developed for evaluating the degree of non-linearity in the power supply mode based upon the hysteresis loop of the material. Drawings of various piezoid fuzes were reviewed and suggestions were made for improving specifications.

The second major area of work dealt with a model for simulating the operation of the entire piezoid power supply. This model was utilized to predict the output voltage as a function of the acceleration profile of the round, the ram weight, and shorting bar closure, in addition to piezoid parameter variation. Use of these models proved to be a valuable analytical tool in studying a design or predicting its performance under normal and abnormal operations.

BENEFITS

This project resulted in the definition of the critical piezoid parameters, a knowledge of their variation under military environment, and enhanced analytical methods for simulating piezoid performance.

These models along with computer models of various rounds has resulted in reduced time and testing required to isolate problem areas.

IMPLEMENTATION

The results of this project have been implemented in developing specifications for piezoids that operate in the storage mode and in other studies, such as:

(1) M409A1E1 Cartridge Airburst Study.
(2) M456A1E2 Premature Investigation.
(3) XM622 Premature Investigation.

MORE INFORMATION

Additional information on this project is available from Mr. J. Bianchi, ARRADCOM, Dover, NJ AV 880-3608 or Commercial (201) 328-3608.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology projects 573 6329, 574 6329, and 575 6329 titled, "Automated Non-Destructive Techniques for Soundness of Materials for Present and Future Generation Artillery Projectiles" was completed in December 1977 at a cost of $694,000.

BACKGROUND

Many artillery projectiles are being fielded with critical defects such as cracks, pipes, heavy inclusions, seams, folds, laminations, etc. The current 100% visual inspection method used at the metal parts and load plants have not been effective in preventing defective projectiles from reaching the field where premature in-bore malfunction might occur. As a result, this MMT effort was initiated to develop an automated non-destructive testing technique to 100% inspect production artillery projectiles.

SUMMARY

The objectives of this effort were to demonstrate that non-contact electromagnetic transducers for exciting and detecting ultrasonic waves could be used to locate critical surface crack-like flaws in artillery projectiles and to determine how these transducers can best be used in a production line environment to achieve high speed inspection.

The ultrasonic inspection of artillery projectiles with non-contract electromagnetic transducers was successfully demonstrated. Electrical Discharge Machined notches of 0.051 CM (0.200 in.) length were placed in several fracture critical locations on both the interior and exterior of three different 155MM projectiles (M107, M107E1, M121). The outer surface defects were detected using both surface (Rayleigh) wave and angle shear waves excited by exterior probes. The interior surface defects were detected by angle shear waves excited by exterior probes and surface waves excited by interior probes. In each case, the signal-to-noise ratio of the defect indication was on the order of 30 dB or greater.

The excellent signal-to-noise ratios coupled with the fact that the transducers did not require a couplant clearly demonstrated that an automatic inspection system at production is practical. Figure 1 is a schematic of the artillery projectiles inspection apparatus used to demonstrate the production practicality.

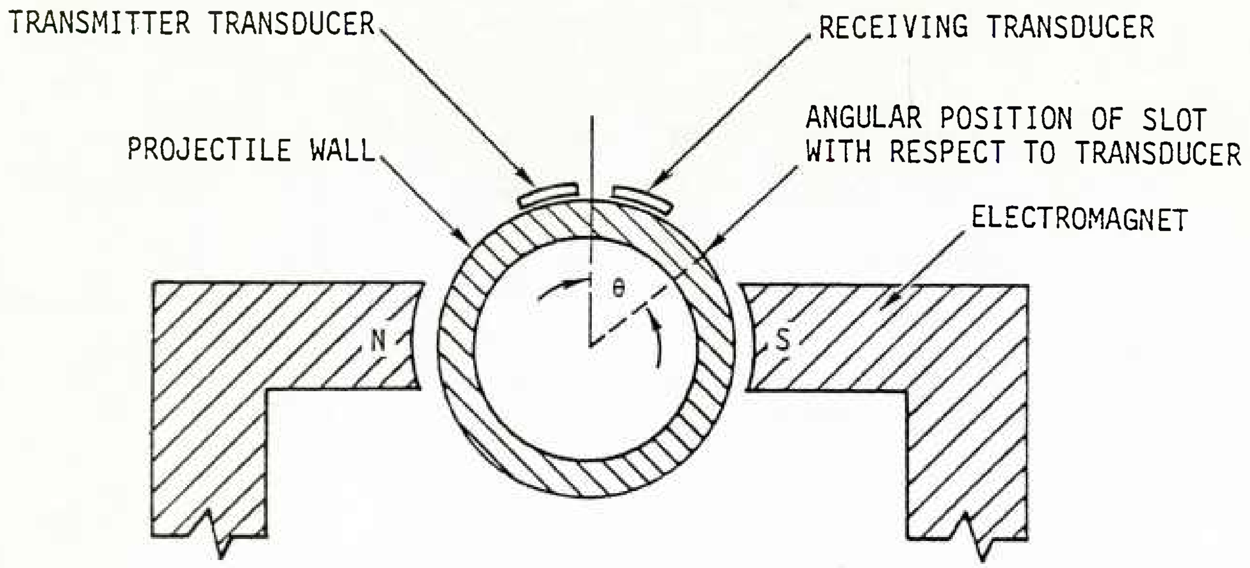

Figure 1 - Artillery Projectiles Inspection Apparatus Schematic

BENEFITS

The potential benefits to be realized from implementing the results of this MMT project are as follows:

a. Elimination of subjective and redundant visual inspection at the metal parts and loading facilities.

b. 100% Non-destructive production inspection of artillery projectiles.

c. Reduction in materials and labor costs.

IMPLEMENTATION

The results of this project are being used to build a prototype Electromagnetic Acousitc Transducer System (EMATS) MMT Project No. 578 6654. This prototype system will be installed and evaluated at an Army ammunition plant.

MORE INFORMATION

Additional information on this project is available from K. Iyer, ARRADCOM, AV 880-3679 or Commercial (210) 328-3679.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 673 7201 titled, "Artillery Weapon Firing Test Simulator" was completed by the US Army Armament Materiel Readiness Command in January 1977 at a cost of $525,000.

BACKGROUND

Artillery and tank weapons and weapon components must be tested during development and production. Most of these tests are carried out by "live firing". Substantial savings would be realized by simulating "live firing" thus reducing testing cost by eliminating ammunition costs and packaging and shipping costs of weapons to and from firing ranges.

A feasibility study (project 672 7201) was performed to determine the best method of approaching this problem.

SUMMARY

Power gymnasticators used to simulate a portion of live test firing were beyond their economic life and did not conform to noise abatement laws. It was planned to replace the powder gymnasticators with new equipment.

Hydraulic simulation equipment to test the XM198 and M110E2 Howitzers at a fixed, low quadrant elevation was designed, manufactured, installed and calibrated under this MMT project. A photo of the XM198 mounted on the hydraulic simulator is shown in Figure 1, next page. Future efforts were planned to qualify the equipment for production testing and extend capabilities to testing at all elevations and to other weapons.

BENEFITS

Use of the hydraulic simulator results in substantial cost savings over the powder gymnasticator and live fire test methods. Noise problems of the powder gymnasticators were partially eliminated and the testing capacity at Rock Island Arsenal was expanded.

Figure 1 - XM198 on Artillery Firing Test Simulator

IMPLEMENTATION

Appropriate personnel have been trained in operating and maintenance of the simulation. The simulator was used for proof acceptance of the XM198 Howitzer and is scheduled for use in production acceptance testing.

MORE INFORMATION

Additional information concerning this project may be obtained from Mr. F. Blessin, AV 793-6745 or Commercial (309) 794-6745, Rock Island Arsenal, Rock Island, IL.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology projects 675 7201 and 676 7201 titled, "Artillery Weapon Firing Test Simulator" were completed by the US Army Armament Materiel Readiness Command in February 1977 and January 1979 at costs of $90K and $365K, respectively.

BACKGROUND

These two projects are the third and fourth phases of MMT program 67X 7201. The objective of this multi-year program was to build a hydraulic simulator that would permit reduction of live firing for tests of artillery and tank weapons. The first phase, FY72, was a feasibility study. The second phase, FY73, covered the building of a hydraulically actuated firing impulse generator. Under the FY75 project, tests were performed to qualify the equipment for production testing of the M198 and M110E2 Howitzers. The FY76 project provided a second impulse programmer to test gun mounts.

SUMMARY

The feasibility of the hydraulic simulator was successfully demonstrated. Original plans called for extending the simulator for the testing of weapons at high quadrant elevations. Necessary requirements were determined for the additional positioning equipment; however, these plans were cancelled due to a change in planned production testing.

The capabilities of the simulator were extended to enable tests of four additional weapons - the M127, M140, M551, and M60A2 gun mounts. See Figure 1, next page. This was accomplished by adding an impulse programmer and impact pads. This made it possible to conduct a large proportion of artillery weapon proof acceptance testing by simulated firing test at a greatly reduced cost.

BENEFITS

Proof acceptance testing of the M140 gun mount was estimated to cost $401 per unit with the simulator. This compares with $485 with the power gymnasticator and $1631 with live firing.

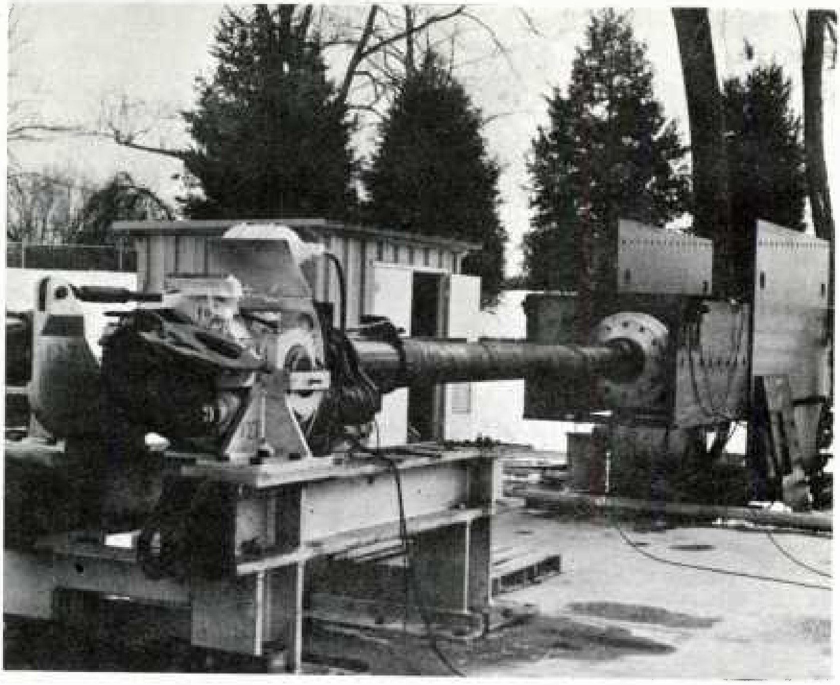

Figure 1 - M127 Mount on Artillery Firing Test Simulator

IMPLEMENTATION

Preparations are currently being made for proof acceptance of M140 gun mounts with the simulator. This involves comparison tests of four gun mounts by each of three methods - simulator, power gymnasticator, and live firing. Production testing in support of the Project Manager CAWS, Project Manager M110, and Project Manager M60 is currently scheduled on the simulator through February 1980.

Implementation will be further enhanced when a second simulator, being constructed under MMT project 677 7201, is completed.

MORE INFORMATION

Additional information concerning this project may be obtained from Mr. F. Blessin, AV 793-6745 or Commercial (309) 794-6745, Rock Island Arsenal, Rock Island, IL.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 672 7226 titled, "Development and Preparation of Multi-purpose Ultra-High Precision Laser Quality Inspection Applications Applied to USA ARRCOM Materiel" was completed by the US Army Armament and Material Readiness Command in January 1976 at a cost of $150,000.

BACKGROUND

Many of the ARRCOM manufactured product test and inspection specifications have been upgraded beyond the dimensional measuring capability of the ARRCOM Product Assurance Directorate's existing equipment.

SUMMARY

The objectives of this MMT effort are to establish a generic ultra high precision Light Amplification by Stimulated Emission of Radiation (LASER) techniques and applications guide for the inspection of complex critical dimensions for ARRCOM Materiel. With the advent of this technology, two basic types of inspection techniques have been developed; the alignment laser and laser interferometer. The alignment laser uses a very straight line characteristic beam. The divergence of this beam is only a fraction of a milleradian making the laser useful in precision alignment applications. The laser interferometer uses a light beam of essentially a single frequency coupled with a short wavelength which permits resolution in the microinch range. The results of this effort has produced an ARRCOM Laser Inspection system application guide and thread measuring and optical measuring system. The guide specifically addresses the following Laser inspection applications:

Application	Laser Measuring System
Cannon Tube Bore Straightness	Alignment
Surface Plate Flatness Calibration	Interferometer
NC Machine Calibration	Interferometer
Length Standard Calibration	Interferometer
Rifling Machine Calibration	Interferometer
Thread Measuring	Interferometer
Optical Component Inspection	Interferometer

The laser thread measuring system, Figure 1, was developed to inspect thread pitch, lead, and deviation from true helical path of large thread plug gages. The Laser Optical Measuring System has the capability to

determine optical glass density, grade carbature, flatness, and scratch and dig characteristics.

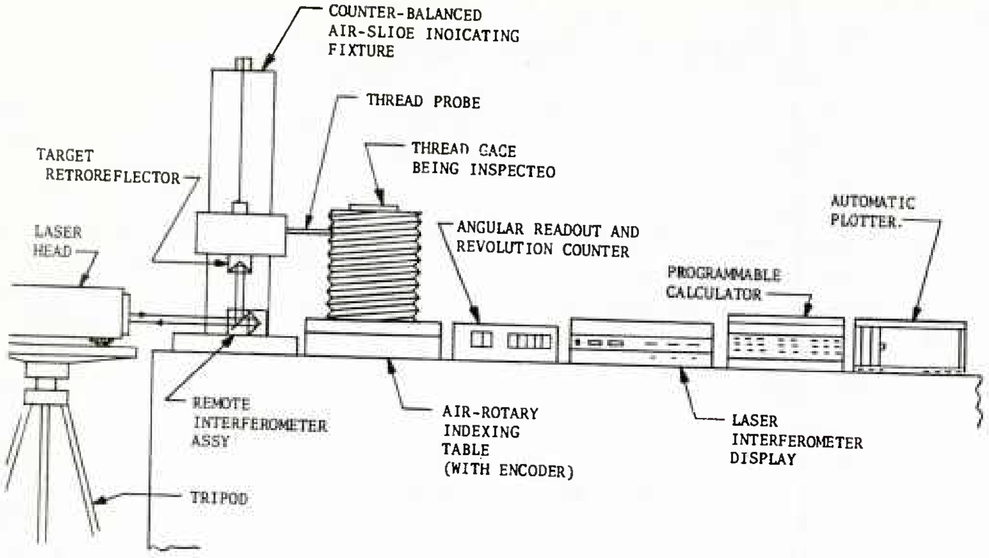

Figure 1 - Thread Measuring System

BENEFITS

The benefits realized from the results of this effort are cost savings and methods improvements.

IMPLEMENTATION

The laser thread measuring system is being utilized in the Watervliet Arsenal Product Assurance Directorate Metrology Laboratory. The laser optical measuring system is being utilized by ARRADCOM's Product Assurance Directorate, Fire Control Engineering Division to: (a) determine optical density of optical filters, (b) determine the grade of optical glass, (c) compare scratches on optical glass, (d) determine curvature on flatness of optical glass.

The Product Assurance Pamphlet AMSAR-WV-P-702-106 has been distributed to the ARRCOM Inspection Community.

MORE INFORMATION

Additional information on this effort is available from Fortune J. Audino, Watervliet Arsenal, Watervliet, NY, AV 974-5328. Reference Product Assurance Pamphlet AMSAR-WV-P-702-106.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 674 7282 titled, "X-Ray Measurement of Residual Stresses Induced in Gun Tubes by Manufacturing Process" was completed December 1976 by US Army Armament Materials Readiness Command at a cost of $110,000.

BACKGROUND

Residual stresses are present in gun tubes either inadvertently due to heat treatment forging, cold strengthening or deliberately due to autofrettage. The effects of residual stresses on the mechanical and physical behavior of gun steel can drastically alter the fatigue properties of the structure causing warping and corrosion cracking. Currently, the only method available to measure these stresses requires the gun tube to be destroyed.

SUMMARY

The objective of this effort was to develop a non destructive automated X-ray stress measuring system that would permit on-line data acquisition and analysis. The system developed by this effort is shown in block diagram form, Figure 1.

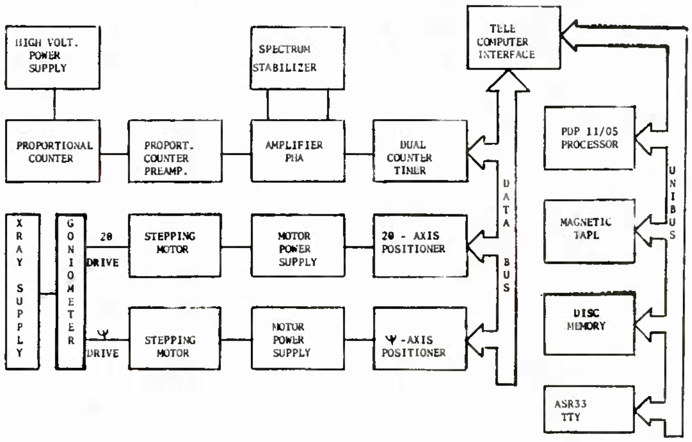

Figure 1 - Block Diagram of the Automated X-Ray Stress System

Basically, there are two X-ray defraction techniques for measuring residual surface stress; namely, photographic and diffractometric. The diffractometric technique was selected for this particular application as it can be completely automated and has the capability to provide a very precise and objective means of locating diffraction peaks commonly found in hardened steels.

The measuring capability of this system is demonstrated by Figure 2 where a theoretical distribution of hoop stress in a 155MM autofrettage gun tube is compared to the X-ray stress measurements. The X-ray stress measurements compare very favorable with the theoretical distribution.

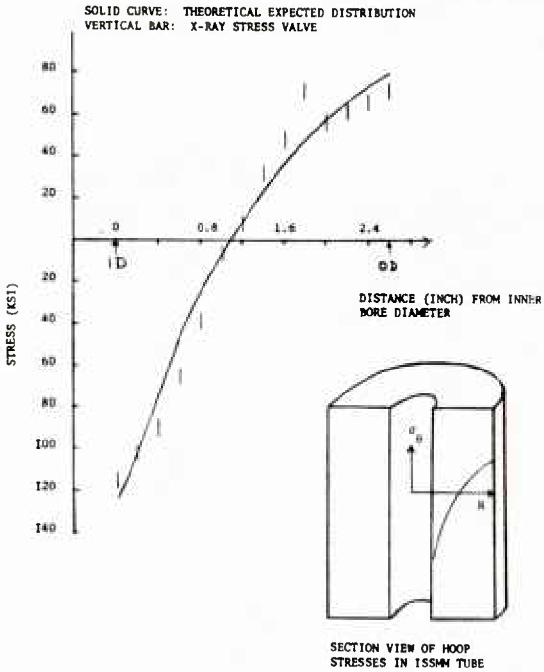

Figure 2 - The Radial Distribution of Hoop Stress in a 155MM Autofrettage Gun Tube

The calibration of this system used a flat rectangular test bar of gun steel using a four point bending fixture where known stresses were introduced and measured by a strain gauge. A comparison of the X-ray measured stresses with the applied measured stresses revealed that a linear relationship exists with only a small deviation. As a result, certain standards and procedures were established for the accurate and reproducible determination of stresses in gun steel.

BENEFITS

The benefits to be realized from the results of this methods improvement are cost savings which will be achieved by the increase in service like of gun tubes and improved safety of the product since residual stresses have a direct bearing on the strength of the gun tube.

IMPLEMENTATION

The results of this effort on automated X-ray stress measuring system are available for implementation. The system has been used on a limited basis to check questionable gun tubes.

MORE INFORMATION

Additional information on this effort is available from G. P. Capsimalis, Benet Weapons Laboratory, Watervliet Arsenal, Watervliet, NY, AV 974-5003. Reference Technical Report No. WVT-TR-77001.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 675 7571 titled, "Shock Test Simulation for Fire Control Instruments" was completed by US Army Armament Materiels Readiness Command in June 1977 at a cost of $148,000.

BACKGROUND

One of the most severe environments a Fire Control Instrument (FCI) can be subjected to is the high intensity shock resulting from firing the weapons. The FCI must not only survive this shock but must function and retain boresight within extremely close tolerances. The current FCI production shock tests have produced unrealistic failure, and as a consequence, the confidence level in these test results is very low. The most prominate problems associated with FCI production testing are increasing the shock level to take into consideration the fatigue level of the material and the directionality of the input shock motion.

SUMMARY

The objective of this effort was to develop improved and more reliable FCI production tests that would produce greater correlation with field firing results. The following FCIs were tested to determine whether there were peculiar characteristics in certain classes which could influence shock test procedures.

(1) Mortar System (M29 81MM Mortar)

- M53 Sightunit
- M128 Telescope Mount
- M109 Elbow Telescope

(2) Artillery System (M102 105 MM Howitzer)

- M14 Quadrant
- M114 Elbow Telescope
- M134 Telescope Mount
- M113 Panoramic Telescope

(3) Tank System (M551 Sheridan Vehicle)

- M127 Telescope
- M149 Telescope Mount
- XM44 Periscope

It was determined that acceptable simulated production tests can be developed from validation test procedures. These production tests can be performed on commercially available shock machines using elastic impact pads which do not require exotic preparation or procedures. Also, it was determined that the 6 millisecond shock pulse durations specified in MIL-STD-810C was too long. Generally, it was concluded that the firing shock environment for these FCI was characterized by short shock pulse durations of 3 milliseconds or less. As a result of this effort, improved FCI production shock test specifications were developed and are summarized in Table 1.

Weapon System	Fire Control Instrument	Axis	Recommended Half-Sine Shock Pulse (g's)	Recommended Half-Sine Shock Pulse (Milliseconds)
M29 Mortar	M53 Sightunit	Vertical (45° to the dovetail axis in both directions)	250	1.
		Transverse (pulling the dovetail away from the sight)	325	0.5
M102 Howitzer	Direct Fire Control	Vertical (up) Longitudinal (forward)	175	2.
		Transverse (outward)	75	2.
	Indirect Fire Control	Vertical (up) Longitudinal (forward)	50	2.
		Longitudinal (aft)	50	3.
M551 Sheridan	M127 Telescope and M149 Mount	Vertical (down) Longitudinal (aft) Transverse (right to left)	150	1.
	XM44 Periscope	Vertical (up and down) Longitudinal (aft) Transverse (right to left)	50	3.

Each instrument is to be shocked a total of 18 times, 6 times in each of the above directions.

Table 1 - Shock Tests Specifications

BENEFITS

This work resulted in improved shock test methods and specifications. Also, the number of shock tests required for qualification testing were reduced by 50%. Cost savings will result due to the reduced number of field firing test requirements.

IMPLEMENTATION

The results of this effort will be incorporated in the production test specifications for the following fire control instruments:

- M53 Mortar Sight
- XM44EI Periscope
- M149 Telescope Mount
- M134 Telescope Mount
- M127, M113, M114 Telescopes
- M14 Quadrant

MORE INFORMATION

Additional information on this effort is available from J. H. Weland, ARRADCOM, Dover, NJ, AV 880-4918 or Commercial (201) 328-4918. Reference Technical Report No. FA-TR-76030.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 675 7572 titled, "Three-Axis Dynamic Simulation of Helicopter Angular Motion for Testing Fire Control Materiel" was completed by US Army Armament Readiness and Development Command in April 1977 at a cost of $128,000.

BACKGROUND

Currently, actual full instrumented flight tests are required to production-test fire control instrumentation. This test method is very time consuming and expensive. As a result, this MMT effort was initiated to determine whether Fire Control Instrumentation could be production tested by using simulated methods.

SUMMARY

The objectives of this effort were to evaluate whether in-flight helicopter vibration conditions could be accurately simulated using the existing Three-Axis Flight Motion Simulator (FMS). The simulation data used for this evaluation was obtained during a flight test of an AH-1 "Cobra" helicopter. The fire control system was placed in its normal operating position and instrumented with vibration transducers and tape recording equipment. When the tape recorded flight test data was compared to the simulated FMS data, a very good match of detail motion was obtained, Figure 1, next page. The results of the effort indicated that the FMS performed well within its capabilities by duplicating the three axis angular motions experienced during the AH-1 flight test.

BENEFITS

The potential benefits that may be realized from implementing the results of this effort are as follows:

1. A fifty percent reduction in the cost of helicopter fire control production testing.

2. FMS may be used to evaluate fire control instruments quality in production.

3. FMS may be used to determine the effectiveness of engineering change modification.

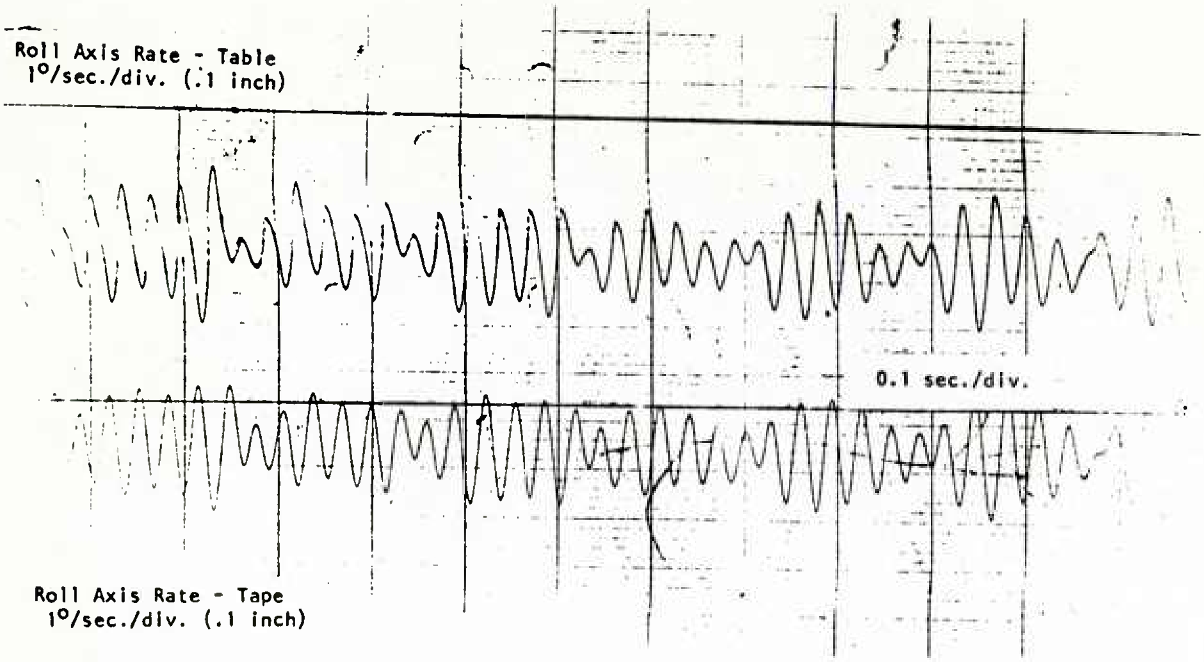

Figure 1 - FMS Table Output Vs AH-1G Helicopter Tape Input: Roll Axis

IMPLEMENTATION

The results of this effort are being incorporated in the detailed production engineering specifications for the XM76 Optical Sight, Airborne Laser Rangefinder, M60 Optical Sight, and M55 Optical Sight fire control instruments.

MORE INFORMATION

Additional information on this effort is available from J. H. Wiland, ARRADCOM, Dover, NJ, AV 880-4918. Reference Technical Report No. FA-TR-77012.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

METALS

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 674 7480 titled, "Application of Electron Beam Welding to Heavy Components" was completed by Watervliet Arsenal in January 1978 at a cost of $115,000.

BACKGROUND

Electron beam welding has long been applied to thin sections with excellent results, but experience on heavier sections (1-1/2 - 4" thick) is very limited. Several items manufactured at Watervliet could have their costs reduced if they could be produced as weldments rather than castings. An example of this is the 155mm muzzle brake for which there is a single source of supply, and which, even as a casting, is difficult to produce.

SUMMARY

The objective was to establish electron beam welding techniques to enable the fabrication as weldments of certain items which are now thick walled castings. The concept was to replace a complex expensive casting with a welded fabrication made up of simple inexpensive forgings.

The item selected was the 155mm muzzle brake. In order to minimize project costs, the project plan called for using forged test specimens to determine weld properties and sectioned cast muzzle brakes to demonstrate the welding fixture and schedule. Forged test samples which varied in thickness from 1/2 inch at their ends to 1-1/8 inches at their centers were used to develop the preliminary weld schedules and to develop operator timing skills needed to control the beam current to thickness relationship. Prototype tooling was developed to accommodate the two cast muzzle brakes supplied by Watervliet Arsenal. The muzzle brakes were cut into four pieces, matching surfaces were prepared, and the pieces were reassembled in the welding fixture prior to welding, see Figure 1. Figure 2 shows the muzzle brakes after welding.

The tensile tests conducted on the forged test specimens show that the welds are of adequate strength since breakage of all specimens occurred in the base material. This also indicated that the Heat Affected Zone tempering had no adverse effect on strength. The hardness traverses indicated that the weld strength was obtained through a high hardness with a resulting reduction in ductility and shock resistance. It was therefore concluded that satisfactory welded assemblies could be made from forgings

(but not castings) which would meet the requirements of MIL-B-12253C, provided they were subjected to a 400°F post weld heat treatment followed soon after by a 1100°F post weld stress relief/tempering treatment.

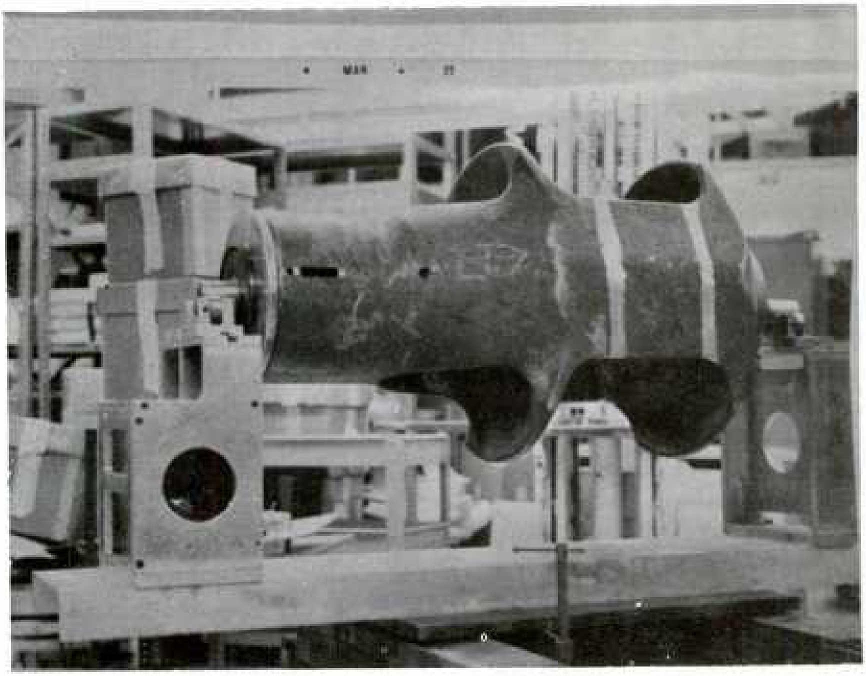

Figure 1 - The Muzzle Brake as Positioned in the Revolving Weld Fixture.

BENEFITS

This effort was initially scheduled to span two years with funding in FY74 of $115K and FY75 of $225K. The initial savings for this muzzle brake was estimated to be $700 per unit at 380 units/year, or $266,000 per year. However, the weldments made from castings were unsatisfactory as stated, and an analysis of the forgings revealed that they would be exceedingly difficult to produce with exhorbitant tooling costs. For these reasons, funding for FY75 was not requested.

IMPLEMENTATION

Although the forged tests specimens passed the physical and mechanical property tests after welding, it was determined that the number and complexity of the forging dies that would be required for the proposed approach increased the costs of the process to point where it was not economical.

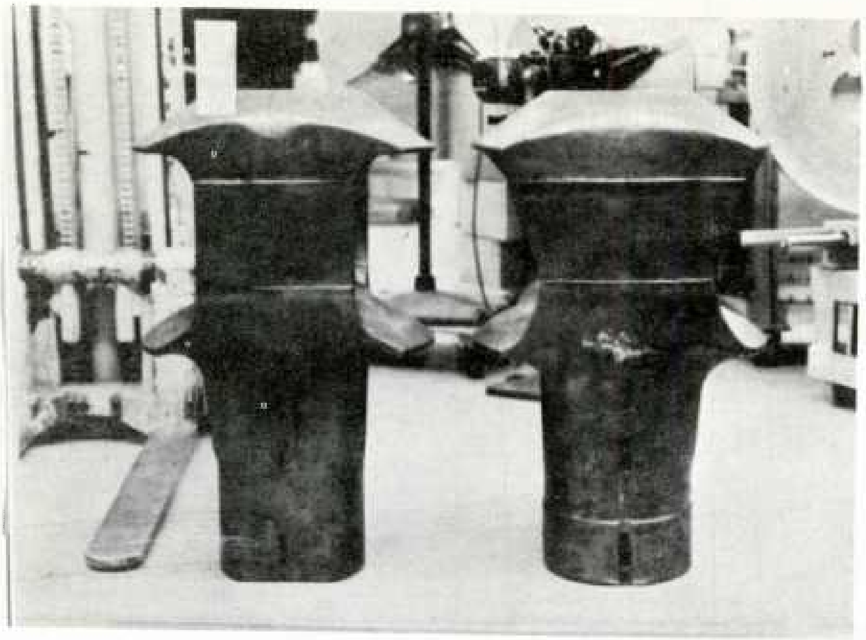

Figure 2 - Welded Muzzle Brake Assemblies, two configurations.

MORE INFORMATION

Additional information on this project can be obtained from Dr. Vito Colangelo, Watervliet Arsenal, AV 974-5517.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology projects 674 7550 and 675 7550 titled, "Development of Prototype Production ESR Facilities" were completed by the US Army Armament Materiel Readiness Command in June 1978 at a total cost of $670,000.

BACKGROUND

Preforms for large caliber gun tube forgings are traditionally fabricated by hollowing-out solid ingots. The technique normally used is trepanning, an expensive process. To eliminate this extra step, a search for a successful technique for casting hollow ingots has been ongoing. Electroslag remelting (ESR) appeared to have the potential of providing high quality hollow ingots. The Russians had applied the process to large hollow tubes and the USAF had awarded a contract to Cabot Corporation to develop hollow thick wall ESR technology for nickel-base super alloys. However, no facilities were available, or planned, for the production of steel hollows of sufficient size that could be used to produce cannon tubes. This project was initiated to adapt ESR to the fabrication of large gun tube preforms and to a prototype production capability.

Three ESR manufacturing methods presently are in use. One is shown in Figure 1.

SUMMARY

The objective of this project was to develop process parameters for ESR preforms, procure and evaluate preforms, and evaluate economics based on data obtained.

Original solicitation resulted in a response from Nutek, Inc., who generated tooling and processing procedures to produce hollows. They delivered one hollow which was acceptable; however, the furnace was not suitable for production because of reproducibility problems.

An in-house capability at Watervliet was established using a furnace available from a previous effort. Considerable problems were encountered and the furnace produced only solid ingots. In-house tests were conducted to determine the fatigue properties of ESR hollows. It was determined that, from a crack propagation standpoint, rotary forged ESR is at least equivalent to standard forged gun steel.

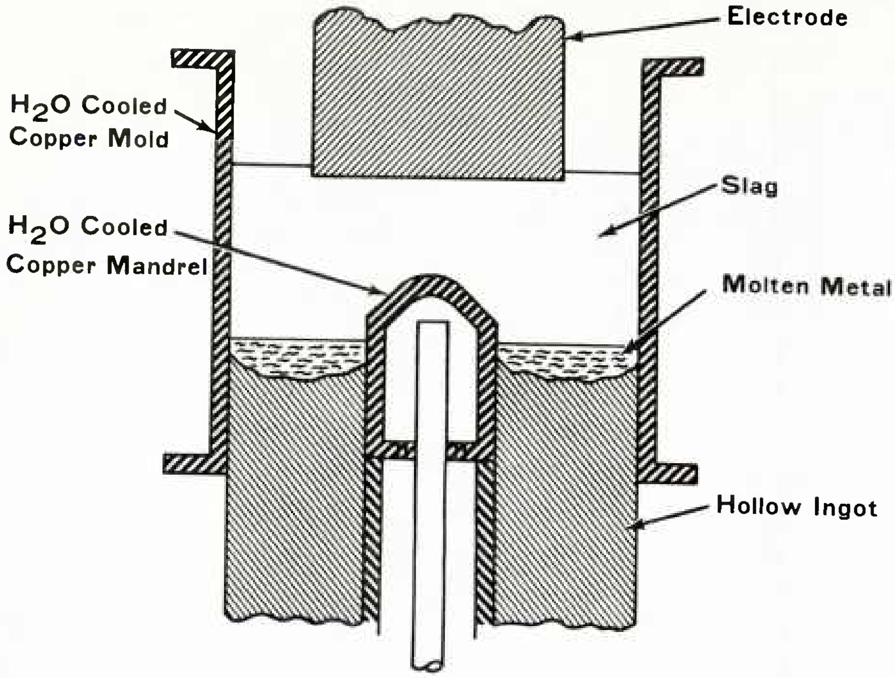

Figure 1 - Hollow ESR Process with Solid Electrode and Bottom Mandrel

Cabot Corporation was awarded a contract to produce hollow ESR ingots from fired-out gun tubes. The hollows delivered were satisfactorily forged into gun tubes. Tests on sections taken from the forgings tested satisfactory and the tubes were used for the production of M68 tubes. The process developed produced high quality, high strength alloy steel economically.

Figure 1 shows the process used by Cabot. It uses a solid electrode and a moving central mandrel. The utilization of the slag is critical. The position of the slag/melt interface must be controlled as well as the composition of the slag. The presence of slag between the mold and the solidified metal results in a smooth ingot surface requiring minimal finishing and conditioning.

BENEFITS

The intended benefits are the cost savings realized by the elimination of trepanning as a production operation. Savings of $500 or more per tube is anticipated.

IMPLEMENTATION

The tubes delivered by Cabot were acceptable to Benet Lab and the

Production Assurance Directorate. A recommendation was forwarded to Procurement to incorporate ESR hollows in the request for quotation for M68 tubes.

MORE INFORMATION

Additional information on this project is available from Mr. V. Colangelo, AV 974-5517. Watervliet Report ARLCB-TR-78016, "Comparison of Properties of Several Heats of ESR Melted 4335+V Steel", is available from Defense Documentation Center (DDC).

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology projects 675 7588 and 676 7588 titled, "Rotary Forge Integrated Production Technology" was completed by the US Army Armament Materiel Readiness Command in July 1978 at a cost of $200,000 and $420,000 respectively.

BACKGROUND

Thick walled cannon tubes have traditionally been forged from an ingot to a solid elongated cylinder after which several machining operations are employed to form a hole the entire length of the tube, and to remove excess stock from the outside. This method is costly and slow and incurs high leadtime.

Smaller caliber gun tubes have been produced by the rotary forge (RF) process since WWII. The equipment appeared to have no design limitation for scaling up to large heavy wall tubes, but no equipment of sufficient size had been produced. Watervliet Arsenal performed studies on rotary forged thin wall 57mm tubes. Data from these tubes, as compared to conventionally forged and machined tubes, showed no decrease in mechanical properties and a distinct increase in fatigue life.

SUMMARY

The objectives of this project were to optimize the process parameters of a rotary forge system that was designed for heavy wall cannon tubes. Various preheating cycles were evaluated. Rotary forge cycles to effect optimum surface finish and dimensional control were established. Feeds, speeds, mandrel material and design, and hammer material and design were established. As a final acceptance test on the forge, twelve 105MM M68 tubes were forged consecutively and automatically.

Computer programs were used in designing tooling and establishing preheat and heat treat parameters. The tool design and load, preheat conditions, and heat treat cycles were successfully established and verified in preliminary acceptance tests. The horizontal heat treat system was evaluated and compared to the traditional vertical heat treat system. Several preforms were investigated including centrifugally cast, vacuum degassed, and electric-slag remelt (ESR). The established parameters were incorporated into the production cycle.

BENEFITS

The results of this program have allowed the development of a viable production process for rotary forging cannon tubes. The data from this program has been used to qualify several sources of preform material, resulting in a potential savings of up to $500 per tube (M68). The installed integrated system is shown in Figure 1.

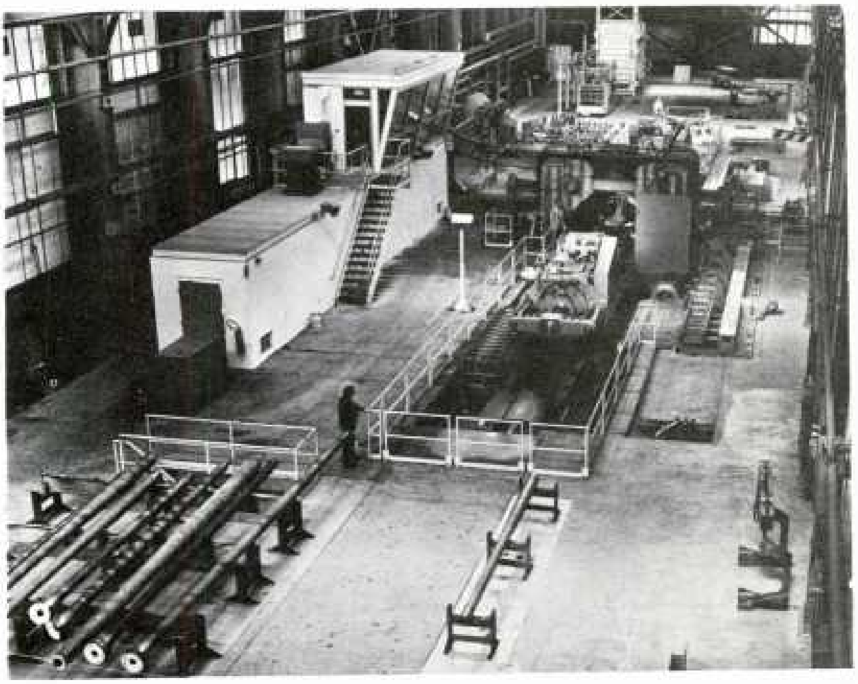

Figure 1 - The rotary forge system undergoing operational prove-out.

IMPLEMENTATION

The data from these projects are being implemented in the integrated tube line at Watervliet. The processing information was disseminated to the Arsenal Operations Directorate and is being used. The approval of alternate materials has been disseminated to the Product Assurance Directorate and the Procurement Directorate in the form of a Tech Data Package for the procurement of material for rotary forging.

MORE INFORMATION

Additional information concerning the project results can be obtained from Mr. L. Liuzzi, Watervliet Arsenal, AV 974-5827.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MUNITIONS

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology projects 376 3228 and 37T 3228, titled "Production Methods for Extrudable HTPB Propellant" were completed by the US Army Missile Research and Development Command in June 1978 at a cost of $95,000.

BACKGROUND

The current production of high volume, solid composite, small caliber rocket motors involves a number of time consuming and costly steps. For example, the propellant is batch mixed, cast into the motor shape, cured, and trimmed. A mandrel must also be inserted to provide the proper geometry and later removed after curing the propellant. Production rates could be accelerated and manufacturing cost reduced by eliminating several of the current motor production stages, and by automating the propellant grain manufacturing operation and the casting and curing of the motors. A continuous automated production cycle is advantageous for certain classes of rocket motors such as small caliber, short burning time, boost and eject motors, and in-tube burning motors.

SUMMARY

The objectives of these projects were to develop the manufacturing methods and technology required to formulate, process, characterize and utilize composite propellants based on the hydroxy-terminated polybutadiene (HTPB) binder system in an extrusion or injection molding process, and to demonstrate the practicality of such a process as a cost reducing method in the manufacture of small high-production-rate rocket motors.

An automated propellant loading and major component assembly system was designed for a full scale motor such as would be used in the VIPER. The propellant was tailored to match the cure rate to the selected injection molding process. Adequate cure levels were reached within five minutes at acceptable processing temperatures. Propellant quick-cure optimization was completed with the definition of catalyst component levels and cure temperature. Sensitivity characteristics of the selected propellant were measured and it was indicated that 300°F would be an acceptable cure temperature. Fabrication of equipment for preparing demonstration motors was completed and trial runs with inert propellant were made. The results of some of these tests are shown in Table 1.

Table 1 - HTPB Injection Test Conditions

Test No.	1	2	3	4	5
Date	7-1-77	7-1-77	7-21-77	7-26-77	7-26-77
Batch Number	5551	5551	5622	5639	5639
End of Mix Viscosity	31.5 Kp @ 120°F		8 Kp @111°F	9 Kp @ 110°F	
Propellant Temperature At Injection Nozzle	117°F	116°F	128°F	108°F	106°F
Motor Case Temperature During Injection	222°F	66-310°F	302°F	136°F	126°F
Injection Pressure	60 psig	60 psig	60 psig	30 psig	30 psig
Injection Time	15 min.	12 min.	2 min.	8 min.	11.5 min.
Heat-Up Time to Cure Temperature	5 min.	--	--	5 min.	7 min.
Cure Temperature	315(224)°F	320°F	303°F	294°F	305°F
Cure Time	4(2.5) min.	12.5 min.	15 min.	10 min.	18 min.
Cool Time	4 min.	5 min.	3 min.	4 min.	5 min.
Cool Temperature	68°F	70°F	68°F	66°F	71°F
Total Cycle Time	30.5 min.	29.5 min.	20 min.	27 min.	41.5 min.
Qualitative Results	OK	Propellant Stuck to Mandrel	Good	Propellant Uncured	Best

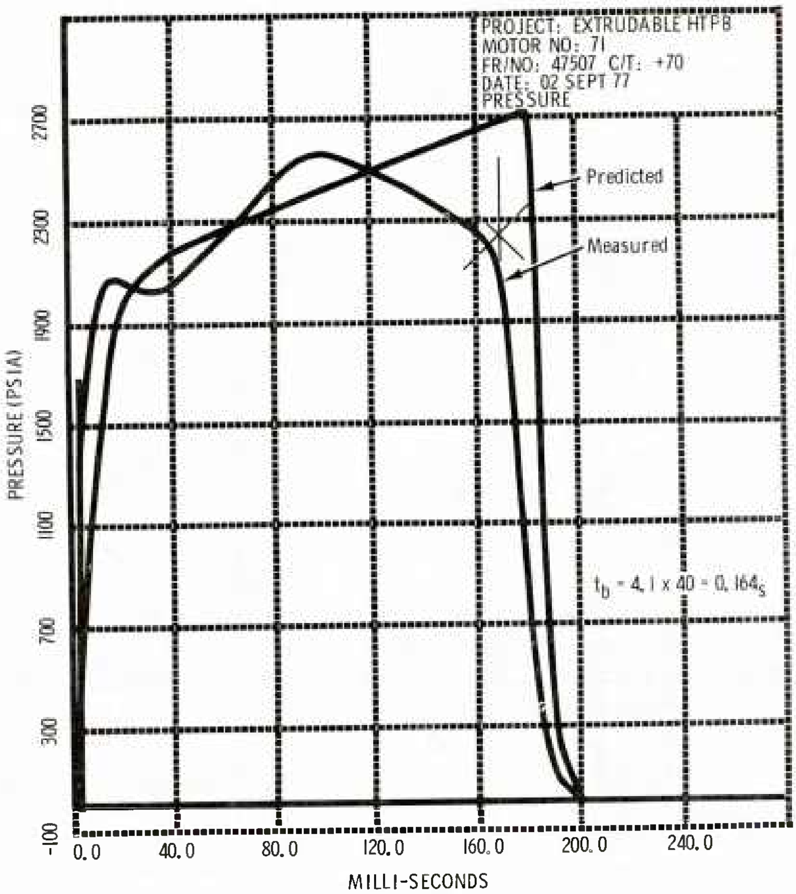

Figure 1 - Comparison of Predicted and Measured Pressure Traces

Limited firings have shown that the injection molded propellant has properties typical of those obtained from normal processing, and that the grain/case bond is adequate. See Figure 1 for a comparison of predicted and measured pressure traces.

BENEFITS

The benefits that are anticipated from the successful completion of these projects include lower production cost of small caliber thin-web motors, improved production base, lower life cycle cost, lower initial investment in casting and curing fixtures and facilities, lower energy use per unit of production, and improved quality control on propellant web.

IMPLEMENTATION

The follow-on FY78 effort includes the fabrication and assembly of approximately 50 VIPER motors by new manufacturing methods which will be provided for validation by production test procedures. Data will also be developed for processing specifications which would include raw material requirements, special equipment requirements, processing data, quality control data and all other related data.

MORE INFORMATION

Additional information concerning these projects may be obtained from Mr. Henry C. Allen, AV 746-1814 or Commercial (205) 876-1814.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 573 1139 titled, "Application of Fluid Logic Control Circuitry to Pyrotechnic Loading" was completed by the US Army Armament Command in May 1974 at a cost of $100,000.

BACKGROUND

This project was a follow-on to two previous projects wherein fluidic elements were incorporated into production prototype systems. The previous projects proved the feasibility of substituting fluidic for electrical circuitry in pyrotechnic and other chemical munition filling lines. However, in the dusty environments which prevailed in some positions on the line and which constituted the potentially most hazardous areas, problems were encountered with the reliable operation of the fluidic devices. These problems caused extensive production downtime for maintenance. In spite of these problems, alternatives to the hazardous spark-producing electrical devices in highly contaminated explosive air environments was needed.

SUMMARY

The objective of this project was to evaluate newly developed fluidic logic elements which in the laboratory demonstrated high reliability performance in dusty environments. Safety would be enhanced through the substitution of fluidic elements for potential spark-producing electrical components in explosion or fire hazard areas.

The results from previous fluidic projects were evaluated and coordinated with the state-of-the-art of pneumatic pressure controls to develop applications of fluid logic control systems. A literature survey of different manufacturers components was conducted for the purpose of selecting a system that could be applied to the binary filling and closing machine. Various sensors and different methods of sensing were studied to determine which would be most applicable to that machine.

Two machines were successfully instrumented with fluidic logic control circuitry. They were the binary filling and closing machine, and the nose closure removal and burster sensing machine. The binary filling machine was designed, fabricated and instrumented for the purpose of filling, closing, and leak checking the difluoro (DF) filled containers for the XM687, 155MM binary projectile. Operation of the machine was completely

automatic except for the manual loading and unloading of the plastic containers. The machine was instrumented and put into operation for the production filling with DF and DF simulant. The fluidic control circuitry operated without any malfunction during the run.

The nose closure removal and burster sensing machine was designed to remove the nose closure and detect the presence or absence of the pyrotechnic burster charge for the 105MM, 155MM and 8-inch Howitzers, and 155MM M122 Gun munitions. Two stations were used to perform these operations. The machine was semi-automatic in operation, in that the operator had to position the impact wrench and adaptor on the munition before removal could occur. Controls were also provided for manual operation during troubleshooting. It was shipped to Tooele Army Depot for installation as a back-up facility.

BENEFITS

The potential for replacing electric control circuitry with fluid logic control circuitry is available. The replacement of electric circuitry with fluid circuitry improves safety as well as operational reliability. Cost savings can be realized from reduced maintenance resulting from increased reliability.

IMPLEMENTATION

As a result of the testing and evaluation of components, fluidic components have been used on a taping machine for the new M18 grenade line to replace inoperable high activation force elements. Other areas of consideration for fluidic applications is a non-contact liquid level detection system for WP level detection which would be similar to the system used on the binary filling machine. Operating this station with a tracer gas would fill the munition with a gas that could be sensed in the leak detection station.

MORE INFORMATION

Additional information concerning this project may be obtained from Mr. Donald K. Patton, AV 584-3895 or Commercial (301) 671-3895.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 573 1155 titled, "Application Study of Programmable Industrial Robots for Production Lines and Demilitarization Projects" was completed by the US Army Armament Research and Development Command, Chemical Systems Laboratory in January 1975 at a cost of $175,000.

BACKGROUND

An ever increasing emphasis on safety in the Department of the Army is spurring a trend to automate and remotely control the handling of hazardous munitions and munitions components.

The application of automated techniques to such operations as explosive packaging, assembly of sensitive components, and demilitarization of obsolete munitions constitute only a few of the many areas in which automation would be beneficial.

Requirements for many functions are unique and demand operations which do not readily adapt to simple automation procedures. An extensive search of available "off-the-shelf" equipment disclosed that the industrial robot incorporated most of the unusual capabilities required to successfully perform the complex operations envisioned as requirements for many of the proposed activities requiring automation. The versatility of movements by an industrial robot is depicted in Figure 1, next page.

SUMMARY

The purpose of this effort was to develop and establish the possibility of employing industrial robots in a hazardous environment. The work was directed toward developing the expertise to either preprogram a robot, or manipulate it from a safe distance, to perform a required function.

The project was divided into three tasks. Task one was performed by the Stanford Research Institute. Their specific objective was to develop a system by which a robot with limited operator assistance would be able to locate, grasp, and remove objects in an unpredictable loaction. A Unimate system was set-up. This system was controlled by voice commands and operated in a manual/automatic mode. The operator talked the manipulator into position directly above the item to be moved, then issued the command "GRAB-IT". This terminated the manual-control phase and initiated the automatic

phase. During the automatic phase, the command computer, interacting with the Unimate, would locate the item, determine its subvolume, grasp it and move the object to a conveyor belt. Feasibility and reliability of this system were satisfactory demonstrated.

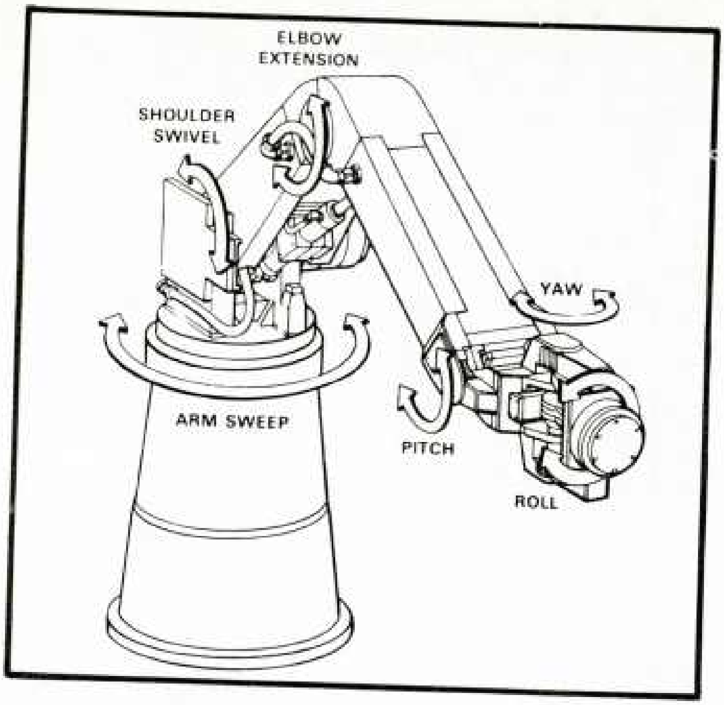

Figure 1 - An industrial robot with six degrees of freedom.

Pine Bluff Arsenal accomplished the second task. Their investigation was concerned with the adaption of industrial robots to function in a hazardous production environment. A Versatran Model E302 Robot was programmed to load two 105mm M60 munitions into a wooden packout box. The program was verified in a simulated production line; however, the robot's cycle time was greater than the required production rate and attempts to decrease the cycle where unsuccessful.

The objective of the third task was concerned with the adaption of an industrial robot to assembly items made up of explosives and other dangerous components. This investigation was carried out at Edgewood Arsenal on another Versatran Robot. The application chosen, which was to insert a M201A1 fuze into a M18 grenade, was successfully demonstrated.

BENEFITS

Based upon the results of this study, the use of robots and robot-oriented system to perform hazardous operations was demonstrated. Labor intensive operations requiring repetative but simple movements can be economically performed using robots.

IMPLEMENTATION

The study recommended that industrial robots be given serious consideration in future modernization plans. Operations suited for employing robots include repetitive type jobs that present an undesirable human environment. Heavy welding and forging operations are likely candidates. Some munitions loading, assembling, and demilitarizing operations can also be readily accomplished with robots.

MORE INFORMATION

Additional information is available from Mr. J. Abbott, US Army Armament Research and Development Command, Chemical Systems Laboratory, AV 584-3418.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology (MMT) projects 573 1248 and 575 1248 titled, "Evaluation of Exhaust Filter Systems to Establish Design Criteria to Meet Air Pollution Standards" was completed by the US Army Armament Research and Development Command in November 1978 at a cost of $190,000 and $254,000 respectively.

BACKGROUND

Preventing the escape of pollutants to the atmosphere is a problem inherent in facilities that produce chemical agents/munitions, conduct agent tests, and demilitarize large quantities of toxic chemical agents. Current filtering systems are comprised of single carbon filters which absorb noxious or hazardous gases and reduce them to an innocuous concentration level. Under controlled-operating conditions, single gas filters will reduce toxic chemical emission to concentrations low enough for exhausting to the atmosphere. Filters can become ineffective in use from three principle causes: (1) physical damage, (2) degradation due to environmental effects, and (3) loading by absorbed vapors during actual use. Techniques now in use are adequate for assessing the effectiveness of filters exposed to physical damage and environmental effects. However, current technology does not provide a method to determine when a filters' sorption life is about to expire. Therefore, technology was required to determine when in-service gas filters become ineffective due to loading by absorbed vapors.

SUMMARY

The major concern of this effort was the performance of gas filters against chemical agents and methods for determining when to replace a gas filter. The only performance data available on gas filters was that on tests conducted at the laboratory scale level. The first objective was to evaluate gas filters quantitatively against chemical agents and establish their performance parameters. In order to meet the requirement for minimizing or eliminating the hazard of effluent discharge of above limits gases, a dual gas filter system series was proposed with a detection/warning capability to monitor the effluent between filters.

The second objective was to evaluate the performance of dual gas filters when connected in series and establish procedures to determine when the filters must be replaced. For the first phase of the effort, four government (MIO, C22RI, C32RI, FFU-17/E) and two industrial gas filters (NPP-2, CTI) were evaluated in this study. The approach was first to use methods

to predict the performance and second to conduct actual tests. The predicted gas lives of the gas filters were estimated by using the Mecklenberg and Wheeler equations and appropriate values for variables taken from the literature. Testing concentrated on such gases as nerve gas simulant (DMMP), nerve agent (GB), phosgene (CG) and cyanogen chloride (CK). The actual performance of the gas filters was accomplished by the apparatus shown in Figure 1.

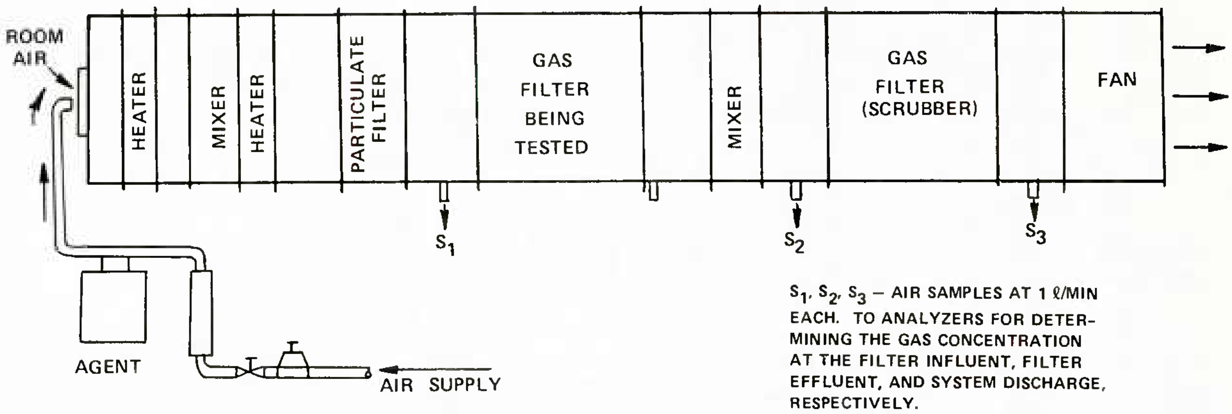

Figure 1 - Test Apparatus for Gas Filters

The apparatus consisted of a 600-cubic ft./min and/or 1220-cubic ft/min blower that drew a gas/air mixture from a mixing chamber, through a mixer, a particulate filter, the filter to be tested, another mixer, and a scrubber gas filter, and then discharged the air into a chamber that also had an exhaust scrubber system. The airflow was controlled by a damper on the blower.

DMMP and GP vapors were generated by spraying the liquid chemical into the mixing chamber where it mixed with air and could be heated with steam coils. CK-air and CG-air mixtures were generated by releasing metered quantities of CK and CG from respective gas cylinders into the mixing chamber. Mixers were used to insure homogeneity of gas concentrations at the influent and effluent ends of the filter.

The results of the performance tests of the six filters indicated the following facts: (1) the actual values for DMMP for C22RI, C32RI, FFU-17/E, and CTI filters were less than the predicted values; and (2) the actual values for GB for all filters were less than the predicted values; and (3) the actual values for CK and CG for M10, C22RI, and C32RI filters were in close agreement with the predicted values. Lower actual values for DMMP and GB were attributed to concentration of test gas being higher than reported and/or the carbon in the filters not being packed to maximum density. Actual values obtained indicated that all the gas filters were serviceable and their gas life exceeded the individual design performance requirements.

For the second phase of the effort, the performance of dual gas filters when connected in series was evaluated. These studies confirmed the following facts: (1) the gas first moves through the carbon bed of the first filter and then through the second filter; (2) when a filter is challenged with a gas, penetration at detectable levels does not occur until a fixed amount of gas has been absorbed by the filter, except for a case when the filter has a mechanical leak; (3) the backup filter will not show penetration at detectable levels until a fixed amount of gas has been absorbed by the filter, except for a case when the filter has a mechanical leak; (4) the summation of each gas life of both filters is equal to that of a filter that has a carbon depth of two combined filters; and (5) the effluent gas concentration of the backup filter will be 0 and/or undetectable at the time of penetration of the first filter.

The following conclusions were made as result of this program: (1) six gas filters (four government and two commercial) were found suitable for use in reducing potential toxic hazards, and (2) the dual filter system with an agent detector is satisfactory for insuring that stack emissions will not exceed the maximum allowed by Government regulations.

BENEFITS

The gas life values of the filters were confirmed to be greater than the individual design filter performance requirements. Data was established that could be used for design and evaluation of air filter systems. It was found that some commercially produced filters were equivalent to government produced filters.

IMPLEMENTATION

The results of this effort will be applied to all future evaluations of engineering design requirements for air ventilation systems. The dual filter system concept has been implemented in the Chemical Agent Munition Disposal System (CAMDS), several small-scale demil operations conducted by the Environmental Technology Division and R&D Laboratories of the Chemical System Laboratory, the air ventilation system at the Aerospace Defense Command (NCMC) and many CONUS fixed installations.

MORE INFORMATION

To obtain additional information, contact the project officer, Mr. M. Schumchyk, AV 584-4351 or Commercial (301) 671-4351.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 574 1260 titled, "Provide Prototype Equipment for Automated Forming and Filling the Starter Cup for AN-M8 HC Smoke Grenade" was completed by the US Army Armament Research and Development Command in June 1976 at a cost of $105,000.

BACKGROUND

The filling of the starter cup for the M8 grenade is currently a manual operation requiring nine operators per shift. Exposure to the atmosphere causes the acetone in the mix to evaporate, changing the mix consistency. This causes the mix to shrink and fall out of the cup. This project was to procure and evaluate a prototype machine to automatically form and fill the starter cups while controlling the mix consistency.

SUMMARY

The objective of this project was to evaluate two procedures for filling the M8 Grenade starter cup with starter mix. The first involved producing a preformed starter slug using a tableting press. The second method was pressing dry starter mix directly into the zinc starter cup.

The method of directly compacting the starter mix into the starter cup was proven feasible. However, the following problems were encountered: (a) difficulty in compacting the starter mix into the cups tapered configuration; (b) difficulty in obtaining the minimum fill even when the cup is filled to capacity; and (c) safety problems with hand feeding the starter cup into the filling machine. Therefore, this method was dropped when the feasibility of producing a preformed starter slug was established.

Starter slugs were made using 1%, 2%, and 3% nitrocellulose binder. Those containing 1% nitrocellulose were weak and friable; 2% nitrocellulose were marginal; and 3% nitrocellulose were strong and crack-free. Based on these results, an experiment was conducted to compare the functioning of the 2% and 3% nitrocellulose levels and to determine whether the slugs should be reconsolidated into the cups.

Results of these tests revealed that reconsolidating the slug into the cup does not enhance grenade ignition. Examination of starter cups produced by the standard Pine Bluff Arsenal (PBA) procedure revealed

that these starter slugs were not bonded to the sidewalls. Therefore, the reconsolidation step was eliminated from future tests. These experiments also revealed that the 3% nitrocellulose slugs were functionally more reliable than the 2% nitrocellulose.

During these tests, an obvious defect in the preformed slug was encountered. The starter mix burn time was too short for reliable HC mix ignition. To alleviate this problem, the die opening was enlarged and the slug configuration was changed to contain a shallower fuze cavity. These modifications seemed to solve the problems. Starter slugs manufactured to this configuration had an average burn time of 1.63 sec compared to 1.53 sec for the standard PBA grenades.

Based on test results, the preformed starter slugs were recommended for filling the M8 Grenade starter cups using a Stokes R4 press; this procedure can produce 1800 slugs per hour. These cup assemblies provide an excellent ignition source for the M8 Grenade.

BENEFITS

This project has resulted in an improved process which reduces manpower by 47% and reduces cost of the end item by $0.056 per grenade. The process also improves safety by greatly reducing the number of personnel in direct contact with a pyrotechnic mix.

IMPLEMENTATION

The implementation of project results has been through the installation and use of a Stokes R4 press at Pine Bluff Arsenal. The funds for purchasing this press was provided in the MMT project. This press is currently being utilized to produce M8 Grenade starter mix slugs. It is also utilized to manufacture starter mix slugs for the 105MM and 155MM Smoke Cannisters.

MORE INFORMATION

Additional information may be obtained from Joe Modisette, Pine Bluff Arsenal, AV 966-2649 or Commercial (501) 534-4600, ext. 2649.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 574 4043 entitled, "Recycle of Anhydrous Spent Acid in RDX/HMX Manufacture" was completed by the US Army Armament Research and Development Command in June 1977 at a cost of $110,000.

BACKGROUND

In the manufacture of RDX/HMX at Holston AAP, acetic acid, acetic anhydride, nitric acid, and ammonium nitrate are used in the nitrolysis of hexamine. These chemicals are used only once and appear in the anhydrous spent acid (ASA) as excesses. The acetic acid and acetic anhydride are converted during recovery operations to 60-80% acetic acid and reconstituted to glacial acid and acetic anhydride. The nitric acid and ammonium nitrate excesses leave the system eventually as sodium nitrate and ammonia at significant processing costs, terminating in a low value product. The concentration and purification of the ASA along with the cost of converting glacial acetic acid to acetic anhydride makes for an expensive recovery operation. Under this project, it was proposed to evaluate the effects of partial or complete substitution of acetic acid and/or acetic anhydride with anhydrous spent acid (ASA) in the nitrolysis of hexamine. The cost of producing RDX and HMX will be reduced if the processing of spent acid could be reduced.

SUMMARY

The overall objective of the program was to establish improved RDX/HMX processes in the nitrolysis and raw materials recovery areas to increase production efficiency and reduce costs.

The concept of recycling ASA involves the reclamation of a portion of the excess rich liquid phase before hydrolysis and recycle it as a heel or as a feedstream without sending it through the total recovery operations. In effect, the recycle stream would be used as a partial replacement for acetic acid and/or acetic anhydride.

The approach was to evaluate the effects of recycling ASA as the heel and of hexamine dissolution with and without neutralization of excess nitric acid by means of bench scale studies of RDX batch nitrolysis. These effects included the affect on pure yield and product composition.

In the HMX batch process, the following changes were evaluated: substituting ASA for acetic acid in the batch heel makeup, using ASA to dissolve the hexamine, using ASA in the acetic anhydride feed instead of acetic acid, and using ASA to replace the acetic acid normally used to make up the volume decrease in the 46% acetic anhydride reduction procedure.

The work was accomplished by bench scale studies at Holston AAP. Studies were performed using three-liter glass-walled reactors, equipped with bottom jackets for heating and cooling, variable speed motors, and reactor tops adapted for feed delivery and temperature monitors. Oversized calibrated glass burettes equipped with feed delivery tubes served as feed sources for hexamine/acetic acid, nitric acid/ammonium nitrate and acetic anhydride. The ASA was recycled to the nitrolysis reactor followed by simulation of the conditions for aging and simmering. After simmering, the slurries were filtered, solids separated, dried and then analyzed for yield and purity.

For the RDX batch process, the recycle of filtered anhydrous spent acid (ASA) as hexamine carrier and batch heel resulted in a significantly lower RDX yield and purity. Removal of nitric acid from ASA by neutralization with ammonium acetate enhanced HMX formation, but significantly reduced RDX yield and purity. HMX enrichments up to 28 weight percent were obtained. This finding demonstrates that reaction promoters can increase the percentage of HMX in the RDX process.

In the HMX batch process, the recycle of ASA as a substitute for acetic acid in the heel and acetic anhydride in the feed (the reduced acetic anhydride procedure) reduced the yield and HMX purity significantly. The RDX content was increased significantly with value of 19 to 30%. The treatment of ASA with ammonium acetate to neutralize the nitric acid and the recycle of the treated ASA in the heel and the acetic anhydride feed reduced the HMX yield but increased the HMX purity significantly. Subsequent recycles (up to four) were comparable to standard reduced acetic anhydride batches. ASA cannot be used as the hexamine carrier for the HMX process because high acetic anhydride excesses in ASA convert hexamine to 1,3-diaceto-3, 7-endomethylene-1,3,5,7-tetrazacyclooctane (DAPT) resulting in serious yield losses. The separation of ASA from crude HMX by filtration was extremely difficult. Filtration times were extremely long, exceeding those normally associated with the reduced acetic anhydride procedure.

BENEFITS

The engineering data obtained indicated that the use of reaction promoters are capable of enhancing the HMX yield in the RDX batch process.

IMPLEMENTATION

A technical report was prepared on this effort. The findings obtained will be used in a follow-on project 575 4252. Before implementing into production, pilot plant testing or production prove-out will be performed.

MORE INFORMATION

Additional information on this project is available from Mr. S. Dollman, ARRADCOM, AV 880-3717, or Commercial (201) 328-3717.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

Manufacturing Methods and Technology project 572 4162 titled "Automated Line for the Melt-Pour Processing of High Explosives" was completed by the US Army Armament Research and Development Command in July 1978 at a cost of $2,045,900.

BACKGROUND

The present melt-pour facilities are antiquated; require high concentrations of personnel exposed to large volumes of explosives. This project was part of a five year funded effort to alleviate this problem by designing and testing an automated production line utilizing improved processes and techniques for melt-pouring explosives. Prior year MMT projects resulted in an explosive preheater, an explosive pump, a controlled cooling procedure for the 175MM projectile, a riser scrap rework system and a modified explosive funnel.

SUMMARY

The overall objective of this effort was to design and test new or improved processes and techniques for melt-loading high explosives. Major tasks undertaken during this project include the investigation of a continuous melting system, automated explosive pouring system, and instrumentation and remote controls to support these systems.

During the investigation of continuous melting systems, Milan AAP was given funds to develop a Minute Melter Concept. The Minute Melter melts the explosive by direct contact with saturated steam, see Figure 1. This system is capable of melting both riser scrap and new flake. Milan AAP designed and fabricated the Minute Melter. Tests were run with Comp B flake and riser scrap and the results exceeded the estimated melting rate of 120 lbs. per minute. The melter was subsequently installed and debugged on the 81MM production line at Milan AAP. Modifications to the melter system to achieve remote control of the entire system was initiated.

The basic construction of the melt-pour pilot plant was completed. This pilot plant is located at Picatinny Arsenal and will be used to evaluate new and improved melt-pour processes.

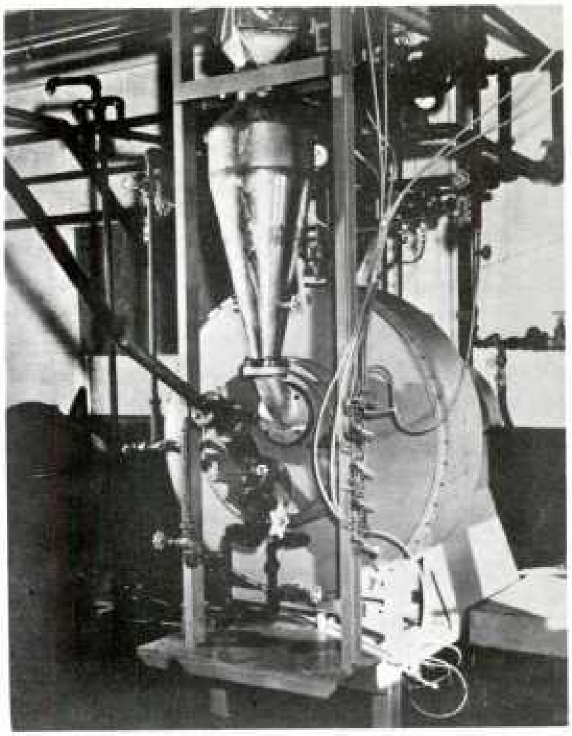

Figure 1 - The developmental model of the Minute Melter at Milan AAP

The design of an automated pouring unit for installation in the pilot plant was completed. This unit has an explosive capacity of 320 lbs. Comp B and will load four 155MM or 8-inch projectiles. With an adapter, it can be utilized to load sixteen 105MM projectiles. The unit also contains two agitators to prevent the RDX from settling out of the explosive. This equipment will be used in evaluating new melt-pour concepts and in controlled cooling studies.

The pneumatic control system logic and circuit drawings were completed for the automated pouring system. Fabrication and initial testing of a model of the level control circuit for the pouring unit was completed. Schematic layouts and pictorial representations were completed for the pilot plant instrumentation, sensors and control system. This entire package was reviewed for safety and design and found satisfactory. These instrumentation and controls will be utilized to remotely control the melt-pour pilot plant.

Other accomplishments of this project include testing of previously developed equipment. The Detonation Trap System was tested with two traps arranged in tandem in a one inch pipe containing molten Comp B. The detonation trap system successfully stopped the detonation. Tests were also performed on the LAAP pulsafeeder pump. During these tests, TNT at temperatures of 207°F and 215°F was successfully pumped through a 52 foot piping loop. The only problem encountered was the deformation of nonmetallic valve parts after prolonged exposure to the molten explosive. Modifications were made to these parts and the pump operated successfully.

BENEFITS

Successful execution of subsequent phases of this program will result in new equipment, processes, and operating procedures for automatic melt-loading of high explosives. Some specific benefits of this project include development of the Minute Melter, design of an automated pouring unit for the melt-pour pilot plant, and design and evaluation of an instrumentation and control system.

IMPLEMENTATION

Data generated during this phase of the project will be used during subsequent phases. Completion of this effort will result in a pilot plant which can be utilized to develop and test improved manufacturing methods and processes for melt-loading high explosives. Ultimately, data generated through this program will result in facilities projects being planned to upgrade the melt-pour facilities.

MORE INFORMATION

Additional information may be obtained from Mr. Curtis Anderson, ARRADCOM, AV 880-3162 or Commercial (201) 328-3162.

Summary Report was prepared by the Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology (MMT) project 573 4162 titled, "Automated Line for the Melt-Pour Processing of High Explosives" was completed by the US Army Armament Research and Development Command in January 1976 at a cost of $1,694,000.

BACKGROUND

The present melt-pour facilities are antiquated; require high concentrations of personnel exposed to large volumes of explosives. This project was part of a five year funded effort to alleviate this problem by designing and testing an automated production line utilizing improved processes and techniques for melt-pouring explosives. Prior year MMT projects resulted in an explosive preheater, an explosive pump, a riser scrap rework system, a modified explosive funnel, the minute melter, and design and evaluation of an instrumentation and control system.

SUMMARY

The overall objective of this effort was to design and test new or improved processes and techniques for melt-loading high explosives. Major tasks undertaken by this project include the installation and testing of the Instrumentation, Control, and Monitoring System (ICMS) for the melt-pour pilot plant; long term explosive pumping tests; and installation of an automated explosive pouring system.

The ICMS installed under this project provides automation of the total melt-pour process thereby eliminating all direct exposure of personnel to explosives. The ICMS is a closed loop feedback system consisting of sensors, servo-mechanisms, and a computer-based controller. Actually, the system utilizes two Real-Time Computers. The first is located in a van outside the melt building to provide minimum response time for closed loop feedback to sensors and controls. The second computer interfaces with the operator's console and the first computer's input/output devices; it performs data logging and processes display data. The ICMS is capable of automatic startup and shutdown, continuous process control, operational safety monitoring, data logging, and maintaining of graphic display maps.

The ICMS was configured as an investigative tool; therefore, flexibility of operator control or intervention was desirable. The operating modes ranged from total operator control to total computer control. Operational safety was assured through special programs which monitor variable signals and compare them to preset limits. If the limit was exceeded, the operator was alerted and overriding action was automatically taken to correct the situation.

Reliability tests were run on the Pulsafeeder Pumping System to determine diaphragm wear characteristics. The test duration was 200 hours representing 200,500 lbs of Comp B pumped. Analysis of diaphragm wear indicated that diaphragm stretching leveled off at approximately 200 hours of operation. This test in conjunction with data on commercial applications of the Pulsafeeder Pumping System indicated that the diaphragm life should greatly exceed 200 hours.

Design and installation of the Automated Explosive Pouring System (AEP) for the pilot plant was completed, see Figure 1.

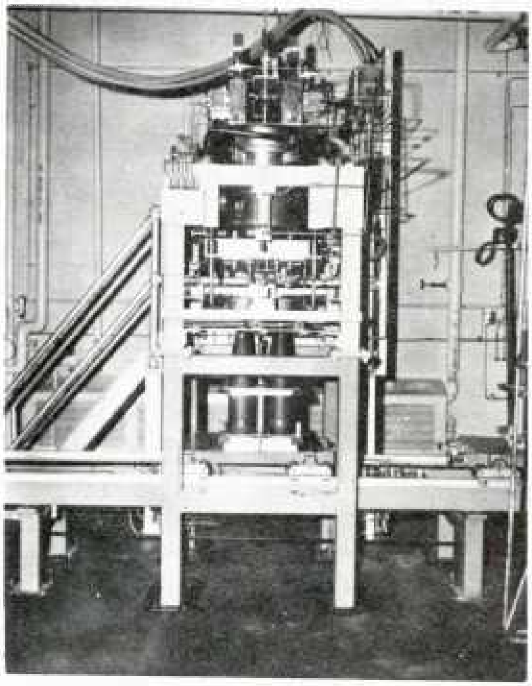

Figure 1 - The automated pouring unit as it is installed in the pilot plant.

The pouring machine consists of a heated manifold of 350 lb capacity, pneumatic sensor probes and plug type pouring valves providing independent control for filling each projectile. This pour machine operates in conjunction with a ground level, power and free, cable driven conveyor that indexes projectiles through the pour machine and associated equipment. Work was also initiated on the AEP/ICMS interface requirements.

Other accomplishments of this project include design of an automated explosive inspection system, process control evaluation, and testing of a TNT and Solids Mixer system. All pilot plant process equipment, instrumentation, sensors, and utilities were installed. Manual check out of all process equipment was accomplished utilizing inert materials.

BENEFITS

Successful execution of subsequent phases of this program will result in new equipment, processes and operating procedures for automatic melt-loading of high explosives. Some specific benefits of this project include installation of instrumentation and control system, design and installation of an automated explosive pouring unit, and long term pumping reliability tests.

The results of this project were used to design a melt-pour production line at Lone Star AAP. Completion of this facility will result in a reduced reject rate, lower personnel exposure to explosive operation, and a decrease of in-process explosives from 15,000 lbs to 3,500 lbs. It is anticipated that cost savings of approximately $1,000,000 per year will be accrued as a result of this facility.

IMPLEMENTATION

Data generated during this phase of the project will be used during subsequent phases. Completion of this effort will result in a pilot plant which can be utilized to develop and test improved manufacturing methods and processes for melt-loading high explosives. Ultimately, data generated through this program will result in design applications in facilities projects being planned to upgrade the melt-pour facilities.

MORE INFORMATION

Additional information may be obtained from Mr. Curtis Anderson, ARRADCOM, AV 880-3162 or Commercial (201) 328-3162.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 574 4162 titled, "Automated Line for the Melt-Pour Processing of High Explosives" was completed by the US Army Armament Research and Development Command in July 1978 at a cost of $1,759,400.

BACKGROUND

The present melt-pour facilities are antiquated; require high concentrations of personnel exposed to large volumes of explosives. This project represents the culmination of a five-year funded effort to alleviate this problem by designing and testing an automated production line utilizing improved processes and techniques for melt-pouring explosives. Prior year MMT projects resulted in an explosive preheater, an explosive pump, a riser scrap rework system, a minute melter, an instrumentation and control system, and an automated pouring system.

SUMMARY

The overall objective of this effort was to design and test new or improved processes and techniques for melt-loading high explosives. Major tasks undertaken during this project included the development and testing of the Porcupine Melter system, integrated testing of the continuous melt-pour pilot plant, testing of a dry mechanical riser crusher, and an automated explosive inspection system.

In the current batch melt-pour lines, the melt vessel contains approximately 3600 lbs of explosive and the building may contain 40,000 lbs of in-process explosives. For the modern melt-pour facility, it was proposed to develop a continuous process thereby reducing the quantity of explosive in the melt facility. To accomplish this goal, a high rate explosive melter capable of continuous melting had to be developed. The Porcupine Processor, used in industry as a heat transfer unit for viscous materials, was evaluated as a viable explosive melter. The heat transfer surface area-to-volume ratio was approximately four times that of the conventional batch kettle. This heat transfer surface in conjunction with the agitation, produced a melt rate capable of sustaining continuous operations.

An automated continuous melt-pour system, see Figure 1, was developed and a 1/10 scale pilot plant constructed at Picatinny Arsenal. The successful operation of this facility for over two years has proved the feasibility of the continuous melt-pour concept. During this time, a

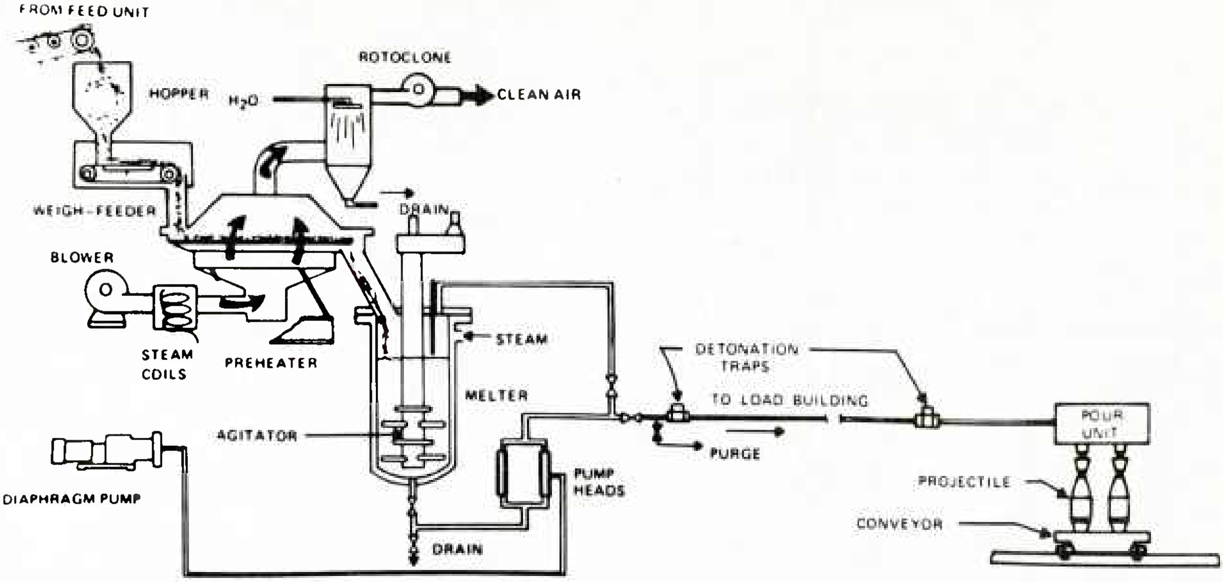

Figure 1 - Continuous melt-pour process flow sheet.

total of 74 test runs were processed utilizing over 33,000 lbs of explosives. Most of the prototype equipment was proven out during these tests and their design was scaled up for the Lone Star AAP MOD project.

A dry mechanical crusher was obtained from the Navy and successfully tested for crushing riser scrap. Crushing of the riser scrap to small fragments was necessary to sustain the continuous melting mode. The risers are crushed with pulsating crusher jaws which are gapped to accommodate specified melting rates. To prevent clogging in the melting system, explosive fines are removed after the crushing operation. Fines, less than one-sixteenth inch cross section, are collected, compressed into pellets by a rotary pelleting press, and returned to the feed stream to the continuous melter.

Iowa AAP designed, fabricated and tested an automated explosive inspection system. During tests, the prototype system was capable of processing over 12,000 lb/hr. It detected and removed all ferrous metal and non-ferrous metals in the form of brass screws and aluminum rivets with 100% reliability.

BENEFITS

The automated, continuous melt-pour concept provides a higher degree of safety, less personnel exposure, lower explosive concentrations, and concomitant cost reductions. This pilot plant will serve as an investigative tool for evaluation of new equipment, processes and operating procedures for automated melt-loading of high explosives.

The results of this project were used to design a melt-pour production line at Lone Star AAP. Completion of this facility will result in

a reduced reject rate, lower personnel exposure to explosives operations, and a decrease of in-process explosives from 15,000 lbs to 3,500 lbs. It is anticipated that cost savings of approximatley $1,000,000 per year will be accrued as a result of this facility.

IMPLEMENTATION

The concepts evaluated in this effort are being implemented through modernization and expansion of the GOCO Ammunition Production Base. The foremost implementation of this project's results is through modernization of the 105MM Melt-Pour Facility at Lone Star AAP. This facility will be a full scale, automated, continuous production line for melt-loading high explosives. Most of the equipment being installed was developed and evaluated under this MMT effort.

Other implementations include modernization of the 60/81MM Melt Pour Line at Milan AAP. This facility will utilize the Minute Melter and an instrumentation and control system. Iowa AAP, 155MM/8-Inch Melt Pour Facility will incorporate the conveyor system, metal parts preheater, explosive inspection, and instrumentation and control system developed under this MMT project. Another implementation will be through the use of this pilot plant to develop and evaluate new processes and equipment for melt-loading explosives.

MORE INFORMATION

Additional information may be obtained from Mr. Curtis Anderson, ARRADCOM, AV 880-3162 or Commercial (201) 328-3162.

Summary Report was prepared by the Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 571 4171 titled, "Investigation of Parameters Affecting the Nitrolysis of Hexamine" was completed in January 1972 by the US Army Armament Research and Development Command at a cost of $250,000.

BACKGROUND

Currently, RDX and HMX based explosives are produced by the Bachman Process, the nitrolysis of hexamine. During the production process, many undesirable by-products are formed which not only minimize the yields of RDX and HMX, but some of these compounds can foul up heat exchanger surfaces and cause difficulty in the filtration operation. This results in a higher cost for the production of RDX and HMX. In addition, there are complex reactions involved in the formation of RDX/HMX which are not completely understood; nor have all of the by-products or intermediates been identified. Improvements in the process, such as varying the modes and ratios of addition of raw materials, amount of raw materials, temperature of reaction, reaction times, and aging times will result in significant cost savings. A laboratory study of the above mentioned parameters was performed to establish the optimum conditions for the improved processes.

SUMMARY

The overall objective of this effort was to establish an improved process for the transformation of hexamine into RDX and/or HMX. Initially, analytical techniques were used to obtain a better understanding of the mechanism of formation of HMX. This was followed by the study of process variables to provide a basis for process improvements.

Laboratory studies were conducted by Illinois Institute of Technology Research Institute (IITRI) to examine the nitrolysis of hexamine reaction. This involved a qualitative and quantitative determination of the intermediates, product, and by-products formed during the reaction. The effort concentrated on the batch process for the production of HMX. The various products and intermediates involved in the HMX process were synthesized at Holston AAP or IITRI. Nuclear magnetic resonance (NMR) techniques were developed and used to identify and quantify the intermediates and by-products. Two undesirable by-products identified were linear nitramines and compound C. In addition, two intermediate compounds 1,3,5-trinitro-1,3,5-triazapentane (TTP) and methyl hexamine dinitrate (MHDN) which were not previously known in this reaction were identified. The

results of these studies then provided the NMR technique a rapid analytical technique for identifying the compounds and a data base for systematically determining the effect of process modifications.

In order to study process variables, a micro pilot plant, 1/3,000 of the Holston AAP batch reactor was designed, constructed, and operated. The reactor system is illustrated in Figure 1. The reactor vessel was a 1000 ml flask fitted with a cover containing four ground glass connections and a mechanical stirrer. A temperature-controlled water bath surrounded the reactor vessel. A cooling coil was submerged in the reactor to control the reactor temperature. The feeds were delivered to the reactor by rate adjustable constant volume pumps. The $HNO_3 + NH_4NO_3$ feed transfer line and storage reservoir were jacketed with 46°C water to eliminate plugging by crystallization. During runs, the reactor was maintained at 43°C.

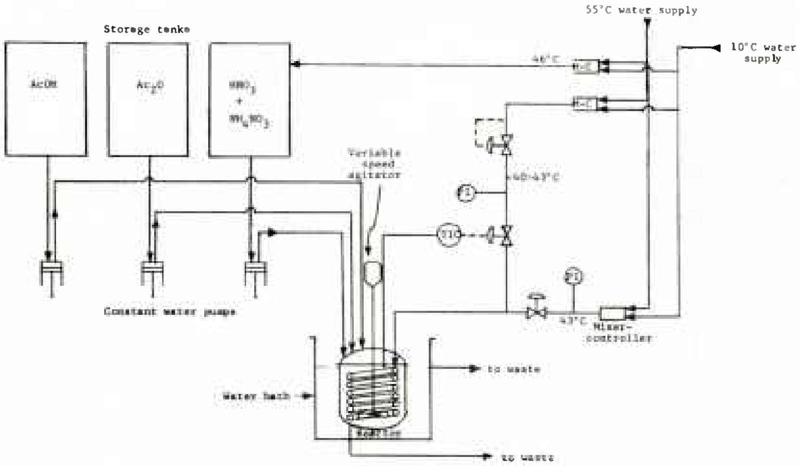

Figure 1 - HMX Micro Batch Pilot Reactor

The laboratory micro pilot plant duplicated the Holston AAP process with remarkable accuracy and was easily adapted for evaluation of process modifications. As a result of the studies, process modifications which could be applied to the HMX process with only minor changes in current operations appeared to have a potential cost savings of up to 21% for crude HMX. Some of the changes which could be applied were:

- Reduction in the amount of acetic anhydride used and replacement with acetic acid.
- Reduction in the amount of nitric acid used.
- Addition of hexamine to the heel.
- Addition of formaldehyde.

o Recycling a portion of filtrate from the end of the run.

The knowledge gained in this study of the batch process served as a basis for the design of a continuous micro pilot plant for further studies of HMX production.

BENEFITS

Under this project, it was demonstrated on a laboratory scale that certain modifications to the HMX process could result in potential cost savings of up to 21%.

IMPLEMENTATION

The process improvements that were indicated by this effort will be evaluated on a production scale in a follow-on MMT project 574 4252.

MORE INFORMATION

Additional information can be obtained by contacting the project officer, Mr. S. Dollman, AV 880-2160 or Commercial (201) 328-2160.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 572 4171 titled, "Investigation of Parameters Affecting the Nitrolysis of Hexamine" was completed in November 1973 by the US Army Armament Research and Development Command at a cost of $98,907.

BACKGROUND

This effort is a continuation of the studies to determine the parameters affecting the RDX/HMX process and establish the optimum operating conditions. Previous laboratory work by Illinois Institute of Technology Research Institute (IITRI) elucidated the mechanism of the batch process to produce HMX and utilized the Nuclear Magnetic Resonance (NMR) technique to identify and quantify intermediate/by-products. In addition, a batch HMX micro pilot plant was constructed and operated to study process modifications. Knowledge gained in this study served as a basis for design of a continuous HMX micro pilot plant. The development of a continuous HMX reactor system would have the advantages of reduced labor cost and reduced quantity of in-process material.

SUMMARY

The purpose of this effort was to study the continuous HMX reactor system on a laboratory scale to gain experience in the operations and to determine problems which might occur in the operation of a large pilot plant and obtain yield and mechanism data.

A mini pilot plant system was designed and constructed by IITRI for the continuous production of HMX. The system was designed with the following goals in mind:

- The feed system was so that feeds to the reactor were variable over a wide range.
- Individual temperature controls were provided for each reactor.
- Reactors were made as small as possible and yet provide the proper heat transfer necessary.
- The feed rates would be adequate to conduct material balances and determine yields.

The mini pilot plant that was designed and built is shown schematically in Figure 1.

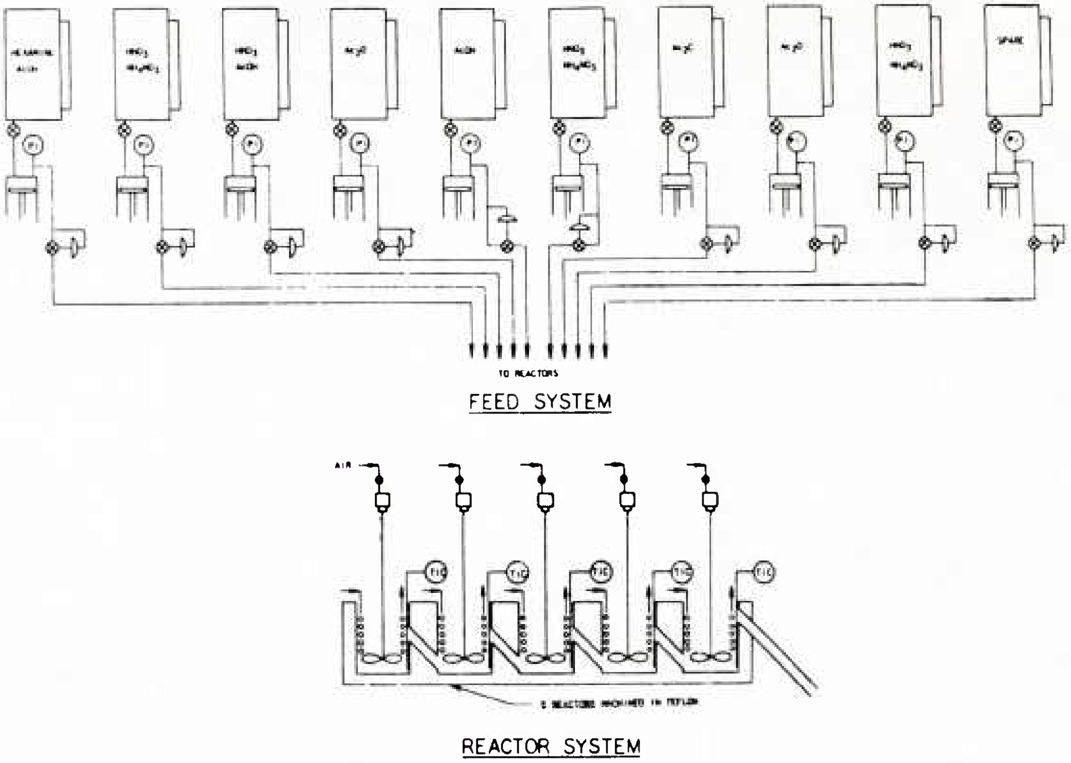

Figure 1 - Laboratory Continuous HMX Reactor System

The feed system consisted of ten reservoirs which supplied constant volume pumps. Feed outlets were placed in a panel board directly behind the reactor system and the feed from any one pump could be directed to any of the reactors by using a short length of 1/8 inch stainless steel tubing. The feed system containing HNO_3/NH_4NO_3 was equipped with a warm-water heating coil to prevent plugging by crystallization of ammonium nitrate. The system operated satisfactorily with good accuracy at rates varying from 0.3ml/min to 15 ml/min.

The reactor system consisted of five individual reactors connected by overflow pipes which would permit the transport of slurry from one reactor to another. The reactor was fabricated from a solid block of Teflon. Each reactor contained a Teflon coated stainless steel cooling or heating coil and Teflon coated double propellers. Each reactor was equipped with a thermistor temperature sensor for control and indication. A fail-safe system was also provided in case of temperature excesses.

The HMX continuous reactor was operated under a variety of conditions in order to obtain information useful in the design of a reactor that would produce HMX at considerable cost savings.

The most promising results were obtained using conditions in which the (1)NH_4NO_3 in HNO_3 concentration was reduced by varying the amounts over the normal Holston AAP usage, (2) the product was removed (by filtration) and the filtrate recycled, and (3) the reduction (20%) of acetic anhydride from that used in the batch process. Increased yields were obtained in these experiments although the feed was reduced as compared to that used in the normal Holston AAP batch runs.

The mini pilot plant HMX continuous reactor was designed and operated in a manner in which the most flexibility of operation could be obtained with minimal operational problems. These ends were achieved.

BENEFITS

This project demonstrated the advantages of a continuous HMX reactor system over a batch system, that is, the reduced amounts of acetic anhydride and ammonium nitrate resulting in cost savings.

IMPLEMENTATION

The process improvements indicated by this effort will be evaluated on a production scale in a follow-on MMT project 574 4252.

MORE INFORMATION

Additional information can be obtained by contacting the project officer, Mr. S. Dollman, AV 880-2160 or Commercial (201) 328-2160.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology projects 574 4204 and 575 4204 titled, "Production Sealing Equipment for Fuzes" were completed by the US Army Materiel Development and Readiness Command at costs of $150,000 and $365,000 respectively.

BACKGROUND

An important fuze requirement is long storage life. Engineering studies have shown that dud rates are directly proportional to storage time. This correlation is attributed to the deterioration of components due to improper seals. Large savings would be attainable across the entire fuze spectrum by reducing the necessity to rework fuze items subject to long storage time.

SUMMARY

The objective of this program was directed toward producing better fuze joint seals under high production rates. Inherent to reaching this objective was the determination of sealants compatible with high production rates, assessment of specific types of fuze seals, application methods, and leak tests. Once this was accomplished, equipment specification would be prepared and released to support fuze production rates.

Twenty-four fuze types were selected at random for consideration of joint design, cost, and effectiveness of seal against moisture. A portion of these fuzes (where test requirements were specified) were tested. Test results clearly indicated those fuzes where joint seal quality was poor and showed that the internal pressure-bubble indication test method is most capable of detecting and locating leaks non-destructively.

A number of commercial adhesives and sealants were evaluated for use as pre-applied sealants. Two showed promise for use on automated munition lines. They were Vibratite VC-3, a red fluorescent lacquer and Weatherban 404L (white) which can be made fluorescent with addition of a suitable fluorescent pigment. Fluorescent characteristic is desirable so the sealant application could be certified with optical detectors when illuminated with an ultraviolet light source.

BENEFITS

This project analyzed and summarized data on fuze joints, sealants, and test methods.

IMPLEMENTATION

Data collected during this project is being applied in the design and production of fuzes. Due to the curtailment of funds, specifications for automated equipment were not developed.

MORE INFORMATION

For additional information, contact Mr. Daniel J. Taravella, US Army Armament Research and Development Command, AV 880-3174 or Commercial (201) 328-3174.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 574 4252 titled, "Improve Present Processes for the Manufacture of RDX and HMX" was completed by the US Army Armament Research and Development Command in October 1977 at a cost of $250,000.

BACKGROUND

Holston AAP manufactures RDX and HMX by suitable adaptations of the basic Bachman Process. Hexamine, ammonium nitrate, nitric acid and acetic anhydride are reacted under controlled conditions to produce either RDX or HMX in separate reactor systems. Recent research of the existing processes on the bench scale disclosed several process variables that affected the yield, purity, production time, and overall costs for the manufacture of RDX/HMX. Two of these variables were, (1) the quantity of acetic anhydride and (2) the quantity of ammonium nitrate. If the use of less raw materials along with improved yields could save both on energy and material costs, then the cost of manufacturing RDX and HMX would be reduced.

SUMMARY

The main objective of this effort was to improve the present process for the manufacture of RDX and HMX. This was approached by evaluating the modifications to the production process at Holston AAP by reducing acetic anhydride and ammonium nitrate usage. In addition, other potential process "improvements" were to be investigated, evaluated, and optimized in a pilot plant under construction at ARRADCOM.

Before implementing the process modifications into production, the following items had to be considered: (1) plant production quotas had to be maintained during process modifications, and (2) precise and complete work plans had to be provided which conformed to the current plant standard operating procedures and the work could be executed by the operators.

To ascertain the effects of the process modifications, two methods were employed. First, plant production records were used for determining cost control and overall efficiency. Then, sampling points and frequencies were determined for collecting samples for laboratory analysis in addition to those normally collected and analyzed during production runs. The analysis of these additional samples provided a better measure of the effects caused by changing the variables in the production process.

The batch HMX process line at Holston AAP was used to evaluate the effects of reducing the quantity of acetic anhydride. The results showed an HMX yield increase of 10.9% for the 25% reduction and an increase of 8.7% for the 46% reduction. Table 1 shows the results that were obtained.

Table 1
HMX Yield Improvements Relative to
Reduced Acetic Anhydride Levels

Acetic Anhydride Level	HMX Yield, lb HMX/lb Hexamine	% HMX Yield Increase
Standard	1.2970	---
25% Reduction	1.4391	10.9
46% Reduction	1.4101	8.7

However, filtration rates for the HMX were slower than normal. This was due to the decreased size of the HMX particles formed. The slower filtration rates led to laboratory studies in an attempt to improve the filterability of HMX. The slow filtration was improved in these studies by using acetic acid to make up for the reduced acetic anhydride volume. The resulting filtration rates were still two to four times slower than standard production rates.

Therefore, the following three variations were put into effect: (a) split each simmer batch and filter separately, (b) increase the temperature during the aging period to increase particle size and (c) addition of a 35-40 inch heel of 80% spent acetic acid to the simmer tank. These steps resulted in larger particles and improved filtration for batch HMX. Filtration rates were improved further by raising the slurry temperature from 50-55°C to 70oC. However, the filtration problem was not resolved completely.

The production scale evaluation of using less ammonium nitrate was begun with a 0.5% reduction. This evaluation was performed without any operating or safety problems for 29 days. However, after the first 18 days, the production records indicated a decrease in RDX yield whereas the laboratory analysis indicated a slight increase of RDX yield. Because of the discrepancies, the ammonium nitrate was reduced an additional 0.5% to a total 1.0% reduction for the remaining test period. The following table summarizes the effect of ammonium nitrate reduction:

Table 2
Effects of Ammonium Nitrate Reduction Upon RDX Yield

NH_4NO_3 Reduction	RDX Yield, lb RDX/lb Hexamine
Standard	2.41
0.5% Reduction	2.47
1.0% Reduction	2.48

However, according to production records, the RDX yield reductions were below Holston AAP's historical yield envelope. Therefore, standard conditions were applied for the remainder of the effort. An RDX/HMX pilot plant was designed to provide a 5-10 lb batch process and a 20 lb/hr continuous process. Construction and installation of equipment is planned for the follow-on effort.

BENEFITS

It was demonstrated that reduced amounts of acetic anhydride produced increased yields of HMX. This could lower the cost of manufacturing HMX.

IMPLEMENTATION

The investigations begun in this project were not completed so implementation in production scale operations was not possible. The information developed was to be applied in the follow-on MMT project.

MORE INFORMATION

To obtain additional information, contact the project officer, Mr. S. Dollman, AV 880-2160 or Commercial (201) 328-2160.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 575 4252 titled, "Improve Present Processes for the Manufacture of RDX and HMX" was completed by the US Army Armament Research and Development Command in February 1977 at a cost of $550,000.

BACKGROUND

This effort was a continuation of process modifications to improve the present manufacturing of RDX and HMX. One process variation identified by earlier research was the use of crude acetic anhydride instead of refined acetic anhydride in the production of RDX/HMX. Acetic anhydride is used in large quantities in the nitrolysis of hexamine and therefore contributes a major fraction of the RDX/HMX production costs. It is presently used once in a single pass and total usages are recovered and reconstituted in the acid recovery operation. The spent acid recovery operation together with the conversion of glacial acetic acid to acetic anhydride makes for a costly operation. The use of crude acetic anhydride would eliminate the need for the current refining operation at Holston AAP. Under this program, the evaluation of the effects of substitution of crude acetic anhydride for refined anhydride in the manufacture of RDX and HMX was determined.

SUMMARY

The purpose of this effort was to determine if crude (80-95%) acetic anhydride could be substituted for pure (99%) acetic anhydride in the manufacture of RDX and HMX. The approach was to investigate on a bench scale, the use of crude acetic anhydride in the manufacture of RDX and HMX. The following areas were investigated: (a) minimum purity of crude acetic anhydride for maximum economic return compatible with Holston AAP existing facilities, (b) analysis of crude acetic anhydride and identification of impurities, (c) reactivity of impurities within various operations and (d) effects of crude anhydride upon product yield and quality.

A chemical analysis performed on the crude acetic anhydride indicated that the acetic anhydride concentration was 80-85% with 15-20% acetic acid and less than 1% low boilers and non-volatiles. A quantitative and qualitative analysis of both the crude and purified acetic anhydride was also conducted. Crude acetic anhydride contained methyl

formate, acetone, methyl acetate, methyl nitrate, ethyl acetate, and butyl acetate. Refined acetic anhydride contained propyl acetate and nitromethane that were not detected in the crude anhydride. The amount of non-volatiles in the crude was 0.062% and in the purified 0.035%. The non-volatiles appeared to be primarily elemental carbon.

The non-volatile contaminants were tested for reactivity with the feed components of the nitrolysis process for thermal activity, by differential scanning calorimetry (DSC) and for compatibility with RDX/HMX by differential scanning calorimetry (DSC) and vacuum thermal stability (VTS) testing. There were no detectable reactions when the non-volatiles were mixed with acetic acid, ammonium nitrate and nitric acid solutions. DSC scans of the non-volatiles exhibited no unusual thermal activity. The DSC scans and VTS test data indicated the non-volatiles were compatible with RDX/HMX. These tests demonstrated that there were no hazards associated with mixing the non-volatiles in concentrated form with either the reactants or the products of nitrolysis.

On a laboratory scale, the substitution of both 80% and 90% crude acetic anhydride for refined acetic anhydride was evaluated for the batch manufacture of RDX and HMX. The RDX and HMX produced were monitored for yield, purity, impact sensitivity, vacuum thermal stability, and differential thermal analysis (DTA). The use of 80% and 90% crude acetic anhydride in the RDX process proved feasible and had no adverse effects on product yield and quality. For the HMX process, the use of 80% crude acetic anhydride proved feasible and it had no effect on the purity but it reduced the crude HMX yield. The use of 90% crude acetic anhydride in the HMX process resulted in no significant differences in yields. For both RDX and HMX systems, there were no significant differences with respect to impact sensitivities, VTS, and DTA.

The results of this study indicate that substitution of 90% crude acetic anhydride in the nitrolysis of hexamine to RDX and HMX had no adverse consequences with respect to product yield or purity. This effort provided the impetus and baseline data for the production evaluation of crude acetic anhydride in the follow-on effort.

An economic analysis comparing the cost of using 80 and 92% acetic anhydride with refined acetic anhydride was prepared. The use of 80 or 92% crude acetic anhydride in the manufacture of batch RDX and HMX generated increased amounts of spent acid which in turn increased steam usage and cost for the evaporative concentration of the acid.

Work on the RDX/HMX pilot plant was continued with procurement of equipment. The plant was expanded to include a distillation column to remove the residual explosives from the spent acid and incorporation of a scrubber system to eliminate contaminants from the effluent gas stream.

BENEFITS

The use of crude (90%) acetic anhydride in the production of RDX/HMX would eliminate the need for the acetic anhydride refining facilities. This would reduce utility, operating, and maintenance costs.

IMPLEMENTATION

The production prove-out use of crude (90%) acetic anhydride was planned to be evaluated in the follow-on FY7T project at Holston AAP.

MORE INFORMATION

To obtain additional information, contact the project officer, Mr. S. Dollman, AV 880-2160 or Commerical (201) 328-2160.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 57T 4252 titled, "Improve Present Processes for the Manufacture of RDX and HMX" was completed by the US Army Armament Research and Development Command in January 1978 at a cost of $390,000.

BACKGROUND

This effort was a continuation of process modifications to improve the present methods of manufacturing RDX and HMX compositions. The FY75 bench scale effort under this project number proved the feasibility of using crude (90%) acetic anhydride in place of refined acetic anhydride and indicated no adverse effects on the RDX/HMX yields and quality. The next step necessary was the production prove-out of the use of crude acetic anhydride at Holston AAP.

Additional areas involving the C-4 and A-compositions were identified as requiring improvements. Composition C-4 is a plastic bonded explosive prepared by coating RDX crystals with a rubber-like material and drying the resultant product. The coating process uses a lacquer which consists of an elastomeric polymer (Vistanex) dissolved in toluene. However, the use of toluene is not desirable because of its suspected toxicological effects. Therefore, a study was needed to select a candidate solvent for replacement of the toluene.

Currently, A-compositions (A-3, A-4, A-5) are prepared by coating RDX crystals with waxes and then drying them in Wolverine Jetzone Dryers. Poor product control and excessive dusting during drying were significant drawbacks in the use of these dryers. New coating techniques were evaluated rather than replacement of the dryers.

The FY75 effort included the procurement of equipment for construction of a pilot plant for RDX/HMX manufacture at ARRADCOM. This effort was continued under this project.

SUMMARY

The objectives of this effort were to (a) evaluate the substitution of crude (90%) acetic anhydride for refined acetic anhydride by prove-out in the production environment and (b) to develop improved coating techniques for composition C-4 and A-compositions.

Crude acetic anhydride (88 percent minimum purity), which had been treated in a distillation column to remove low boilers, was substituted for refined grade acetic anhydride (97 percent minimum purity) in the production of RDX. No unusual safety hazards resulting from the substitution were discernible in any production process or product. The RDX produced was successfully processed and used for the production of finished explosives without any effect upon safety or product quality.

Several minor processing differences occurred during the prove-out. There was increased coating of the vacuum lines and in the bottoms of the batch filtration tanks. The increased coating caused decreased filtration rates for crude RDX. This coating could be reduced by adding excess nitric acid in the nitrolysis process. In addition, there was an accumulation of ferric phosphate in the stripping column in the primary distillation process. This required more frequent column shutdown and cleaning.

A review of prior work on Composition C-4 and a compilation of physical and chemical characteristics for a replacement solvent for toluene was conducted. The following factors were used to select a replacement solvent: flashpoint, possible carcinogen, toxicity, and the dissolution of Vistanex. The only solvent that was found safer than toluene was n-octane. N-octane is less of a fire hazard than toluene and is not a suspected carcinogen.

The dissolution of Vistanex in n-octane was found to be greater than in toluene below 80°C. The rate of dissolution of Vistanex in either solvent is directly proportional to the absolute temperature and inversely dependent on the minimum dimension of the Vistanex solid. The agitation rate in the dissolving vessel was at the minimum required to suspend the solid Vistanex. Specification grade Composition C-4 was successfully made in the laboratory using n-octane as the lacquer solvent.

A modification of the Wabash method was tried in which the Vistanex was dissolved in n-octane and then two plasticizers, dioctyl adipate and motor oil were added. After the n-octane was driven off in a heated horeseshoe agitated pot, oven dried RDX (Class 1 and 5) was added. The binder and the RDX would not mix until water was added (5% by weight). The batch produced met specifications but lumps of binder remained in the pot after discharge.

Various techniques for the coating and dewatering of Composition A-3, A-4, and A-5 were evaluated. The coating techniques were: dry coating, solvent wax coating, and water slurry coating. Extensive testing indicated that the dry coating techniques for product A-3 and A-4 were not feasible.

Qualitative solubility information was determined for several solvent/wax systems in regard to the coating process for Compositions A-3 and A-4. Those solvents tested for solubility of Witco wax included naphtha, n-octane, hexane, isobutyl acetate, butyl acetate, methyl-ethyl-ketone, and

cyclohexane. Of these, only naphtha and n-octane showed any significant capability for dissolving the wax.

N-octane/wax and naphtha/wax solutions were used to produce batches of Composition A-3. Two techniques were used to produce these batches: (a) Solvent/wax was added to the RDX slurry and a batch distillation was performed to strip the solvent/water azeotrope, and (b) the solvent/wax was added slowly to the RDX slurry which was held at a temperature two to four degrees Celsius above the solvent's azeotropic boiling point, thus allowing the solvent to mix with the water and flash to produce a "continuous" distillation process. For both techniques, the A-3 produced had a uniform particle size and coating with no uncoated RDX present. The effects of RDX slurry concentration and distillation temperature were studied with regard to the continuous distillation process. Slurry concentration was varied in the range of 10 to 20 weight percent solids. For a constant temperature and agitation, a much finer granulation formed when using a 10% slurry as compared with batches employing 14% and 20% solids slurries. The same effect was noted when slurry concentration and agitation were held constant and the slurry temperature was varied. The particle size of the A-3 produced at the lower temperature was finer than for batches produced at the higher temperature.

Work on installation of the RDX/HMX pilot plant was sub-contracted. Installation began in July 1977. All equipment was received and installed. After modifications for safety requirements are made, a checkout of the system will be conducted under the follow-on project.

BENEFITS

It was demonstrated in production facilities at Holston AAP that crude (90%) acetic anhydride can be used to produce RDX without affecting yield or quality of product. However, there are no cost savings associated with using crude acetic anhydride because of the increased demands in the supplementary recovery operations.

IMPLEMENTATION

Due to operational problems and the unfavorable economics, the use of crude acetic anhydride for RDX production at Holston AAP was not implemented. The effort on C-4 and A-compositions will be continued under project 577 4252.

MORE INFORMATION

To obtain additional information, contact the project officer, Mr. S. Dollman, AV 880-2160 or Commercial (201) 328-2160.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 574 6609 titled, "Ball Propellant Hardening Still Cleaning System" was completed in May 1976 for the US Army Armament Materiel Readiness Command at a cost of $63,700.

BACKGROUND

During the hardening step in Ball Propellant Manufacture, a nitrocellulose (NC) coating accumulates on the interior walls of the stills. This film which can build up to more than three inches thick must be removed at regular intervals. The cake decreases heat transfer efficiency, and if allowed to build up too much, it could become overheated which in turn would cause decomposition and even an explosion.

The conventional method of removing the deposits is by operators physically entering the unit through a manhole and removing the material with nonsparking hand tools. This subjects the operator to a health hazard because of the presence of ethyl acetate and benzene fumes in the still. There is also a serious safety hazard because the impact energy to remove the film could exceed the impact energy to initiate an explosion or start a fire.

SUMMARY

The purpose of this project was to design, install, and evaluate a prototype remotely-operated tank cleaning system for removal of the NC film cake without entering the vessel. Several manufacturers of potentially suitable equipment were contacted. Their responses were narrowed to two principal alternatives, both of which used a pipe lance with a nozzle which rotates in two planes to insure coverage of the entire internal surface of the vessel. The first approach used high pressure (1800-2000 psi) water and the second used medium pressure (200-300 psi) water and solvent mixture. The second system would recycle the water and solvent for removal of the dissolved NC.

For a selection to be made, tests were conducted with special films cast on stainless steel plates. Efforts to find a suitable solvent for the second type system to work properly were unsuccessful. However, the high pressure water gun removed the NC film in less than 10 seconds from a distance up to four feet. Therefore, the prototype cleaning system was based on high pressure water alone.

The system, which is shown schematically in Figure 1, consists of a rotating nozzle, a properly sized manhole cover with a telescopic lance (so that the nozzle could be located anywhere within the still) and a high pressure hose.

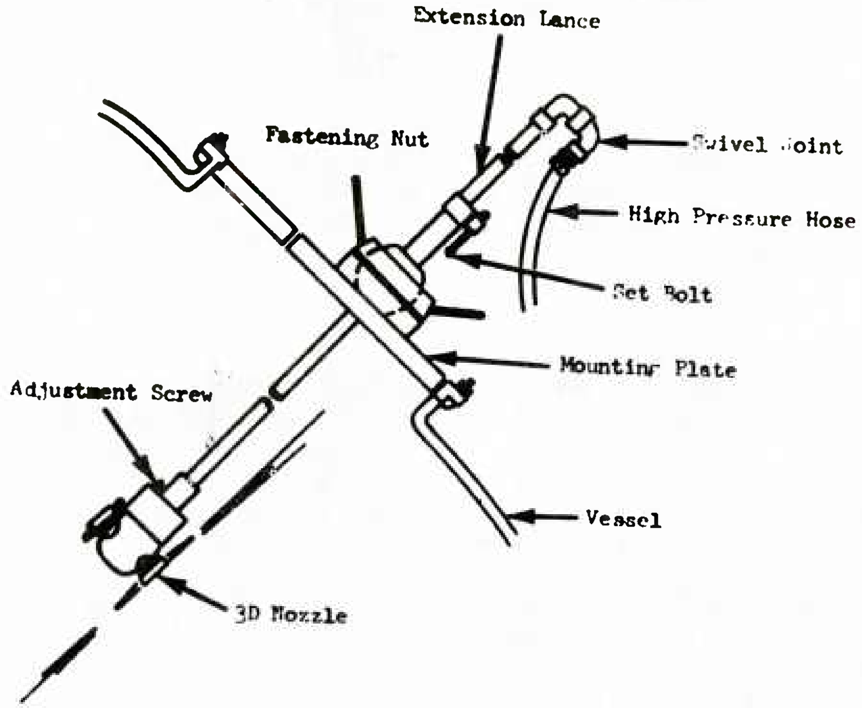

Figure 1 - Prototype Cleaning System

The prototype system was tested by first casting a one to three inch NC film on the internal surface of a 1000 gallon still at Badger AAP. The prototype cleaning system was inserted in the vessel and the NC was successfully removed. Some larger pieces which were not completely flushed through the drain valve were broken up by the cleaning system and then easily drained from the still.

BENEFITS

The high pressure cleaning operation is efficient and can be done remotely, thereby eliminating the safety and health hazards associated with personnel entering the still to perform the same function. There is a significant time saving because a job which might take up to two days with conventional hand cleaning can now be carried out in an hour or so. Cleaning is even more complete as the high pressure water stream also removes any loose scale or rust on the inside of the vessel.

IMPLEMENTATION

The prototype system has been used regularly at the pilot plant at the Badger AAP. A similar system without the special head is being utilized now in the St. Marks facility in Florida. With minor modifications, it could be used for cleaning accumulated deposits from the interior walls of any number of types of process vessels.

MORE INFORMATION

Additional information may be obtained by contacting Mr. Joel M. Goldman at AV 880-4615/6450 or Commercial (201) 328-4615/6450. Technical Report FA-TR-76013 covering the results of this effort was completed, reviewed and published (May 1976).

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

NON-METALS

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project Q75 8035 titled, "Automated Production of Insulated Footwear" was completed by the US Army Natick Research and Development Command in January 1978 at a cost of $310,000.

BACKGROUND

The insulated boot, currently used by the Army Services, is fabricated by techniques that are becoming obsolete in the footware industry. The procedure involves many hand operations and consists of the hand lay-up of 44 component pieces over a footwear last. The various parts are formed into a unit through the use of adhesives. The resultant boot is functionally adequate but suffers from the drawback of excessive weight and a rapid loss of insulating properties when the outer protective layer is torn or punctured.

An expanded improved polyurethane pull-on type insulated boot, Figure 1, consisting of five component parts has been developed. This new insulated boot is lighter than standard insulated boots and insulating properties are not affected when punctured. Experimental boots have been produced on manually operated pilot plant equipment; however, there is no known industrial capability for mass production in accordance with present design and physical property requirements.

SUMMARY

The objective of this project was to establish the necessary production equipment requirements to set up an automated production facility to produce the polyurethane pull-on type insulated boot. Production methods and process descriptions were prepared and a boot fabrication technique developed. Manning requirements were determined, a list of materials was prepared, and chemical storage requirements determined. Boot acceptance standards, packaging methods, and warehousing requirements were proposed. User instructions, mold requirements, typical equipment layout, operations process chart, and last grading schedules were developed. Equipment requirements were tabulated.

BENEFITS

The cost of insulated footwear items will be reduced by the establishment of manufacturing technology and quality assurance information for producing insulated footwear on an automated production basis. The availability of this automated process will result in lightweight insulated footwear

for which insulation will not be affected, even if punctured, thus eliminating the possibility of frostbite.

Figure 1 - Polyurethane Insulated Boot

IMPLEMENTATION

The manufacturing technology for this new method of fabricating insulated footwear will be made available to industry. The specification will be revised to require the use of this manufacturing tecnnology. A follow-on MMT project Q76 8035 is in progress. This project will provide the Government with an automated industrial capability. A prototype line will be established.

MORE INFORMATION

Additional information on this subject is available in US Army NATICK Research and Development Command's Technical Report Number TR-78/004, titled "Automated Production of Insulated Footwear", dated June 1977. The project officer is Mr. J. Assaf, AV 955-2607 or Commercial (617) 653-1000, ext. 2607.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology projects 174 8109, 175 8109, and 176 8109 titled, "Fluidic Devices for Aircraft Stability Augmentation Systems" were completed by the US Army Aviations Systems Command in January 1978 at a cost of $574,000.

BACKGROUND

The stabilization equipment used in Army aircraft utilizes electro-mechanical devices to perform essential operating functions. In numerous instances, environmental operating conditions have reduced performance and reliability. Fluidic servo devices are more reliable and have the potential to be manufactured more efficiently and may be more cost effectively used in Army helicopters as well as other possible applications. Previous R&D work has investigated several methods of fabricating fluidic devices. Fabrication techniques involving etching and diffusion bonding, electroforming, investment casting and optical milling had been evaluated. Only electroforming (electroplating over conductive wax) has fully eliminated the leakage problem associated with fluidic devices.

Project work was accomplished by in-house efforts at USAAMRDL and USAAVRADCOM, and contractual effort at Honeywell Inc., Government and Aeronautical Products Division, Minneapolis, Minnesota.

SUMMARY

The objective of this project was to determine the production suitability of the Electroform Conductive Wax (ECW) process in conjunction with existing conventional processes for the manufacture of fluidic systems. Experimental fabrication technology, developed under R&D effort, was reviewed and manufacturing procedures were developed.

This project was conducted in three phases. Phase I was the design, fabrication and qualification testing of an integrated amplifier-manifold hydrofluidic stability augmentation system using the ECW process. Also, a pilot production line using the ECW process was defined which includes all manufacturing, inspection, and assembly equipment needed. The effort did prove that amplifiers, resistors, and interconnecting channels can be incorporated on an integrated circuit manifold.

Phase II consisted of the manufacture, assembly and checkout of the complete production line designed in Phase I. Three lots (each lot consisted of three sets of hardware) of system components using the Phase I

production line were fabricated and tested. A complete system from each lot was tested and analysis of the test results was made to determine the need to modify the design, the ECW process, or process equipment before fabrication of the next lot. Three "through rate" resistors failed during proof pressure tests due to insufficient plating thickness in areas of relatively sharp inside corners in the resistors. Elimination of these sharp inside corners provided the solution to the problem.

The last phase of the program consisted of a small "proof" production run. It was accomplished with production-oriented personnel operating the production line that was established during Phases I and II, and during this prove out run, 20 Hydrofluidic Stability Augmentation Systems were produced. All components were completely tested and then randomly assembled into systems. These systems were then evaluated and the test data was documented. Figure 1 is an exploded view of the controller hardware showing its major components.

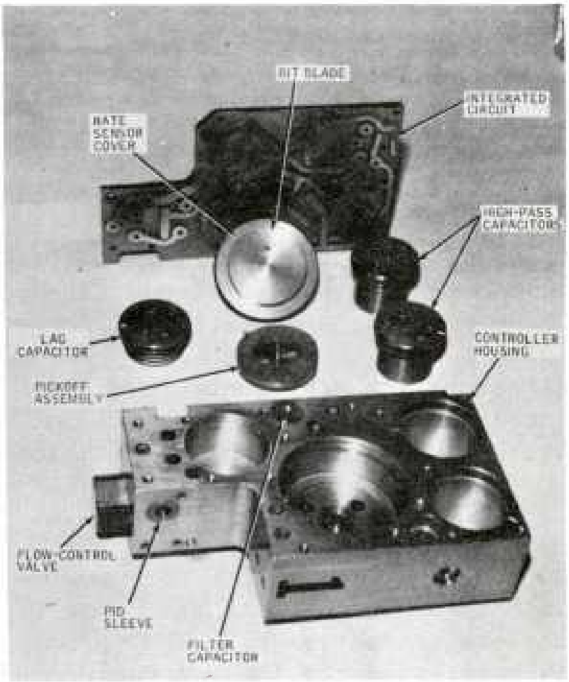

Figure 1 - Major Components of a YAW Controller

The most complex and largest electroformed component in the YAW controller was the integrated circuit, officially called the amplifier-manifold.

The conclusions of this program were that electroformed components can be fabricated in large quantities with high degrees of repeatability and with initial yields of 90 percent for complex circuits and nearly 100 percent for simple devices. With normal process refinements and operator skill improvements, yields should increase to more than 95 percent for complex devices. The ECW process in conjunction with existing conventional processes is suitable for quantity production of fluidic systems.

BENEFITS

A manufacturing process for the fabrication of more reliable, less costly fluidic systems was developed. This process will enable those devices to be more efficiently and cost effectively used in aircraft flight control systems as well as many other possible applications. The proposed fluidic system was estimated to cost 30% of the current electro-hydraulic system.

IMPLEMENTATION

A Technical Data Package was prepared that is suitable for the Government to conduct a competitive procurement for the fabrication of hydrofluidic stability augmentation systems. Final reports were distributed to Army Aircraft Project Managers, AVRADCOM/DARCOM Product Assurance, Maintenance, Systems and Production Directorates and other cognizant Army activities.

MORE INFORMATION

Additional information on this project is available from Mr. George Fosdick, Eustis Directorate, USAAMRDL, AV 927-4209. Reference Technical Report Nos. USAAMRDL-TR-75-49, 76-42, and 77-2.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 274 9470 titled, "Manufacturing Methods and Technology Measure for the Production of Fast-Rise, High Altitude Meteorological Balloon ML-566" was completed by the US Army Electronics Command in August 1976 at a cost of $97,000.

BACKGROUND

Poor performance characteristics such as insufficient altitude and ascent rate were responsible for obtaining inadequate weather information from radiosondes carried aboard weather balloons.

The ML-566 (XE3)/AM balloon is a fast rise, hydrogen filled, double enveloped balloon required to reach an altitude of 30 kilometers (approximately 100,000 ft.) at a rate of 1700 ft. per minute, both by day and night under all climatic conditions.

Major performance improvements, such as a 60% increase in rate of rise for night flights were attributed to changing the outer balloon from neoprene to rubber and were the result of previous R&D efforts. The MIL-566 (XE3)/AM is a spherical shaped balloon and consists of the following major items:

a. Neoprene inner component
b. Natural rubber outer component
c. Neoprene neck component.

See Figure 1, next page.

SUMMARY

Kaysam Corporation of America established the production processes for the natural rubber outer envelope, determined optimum assembly procedures and post-assembly processing, and developed quality control methods and special tooling. They performed the following work:

a. Determined liquid rubber latex parameters, such as chemical formulation, dip and withdrawal times, temperature limits and permissible latex aging.

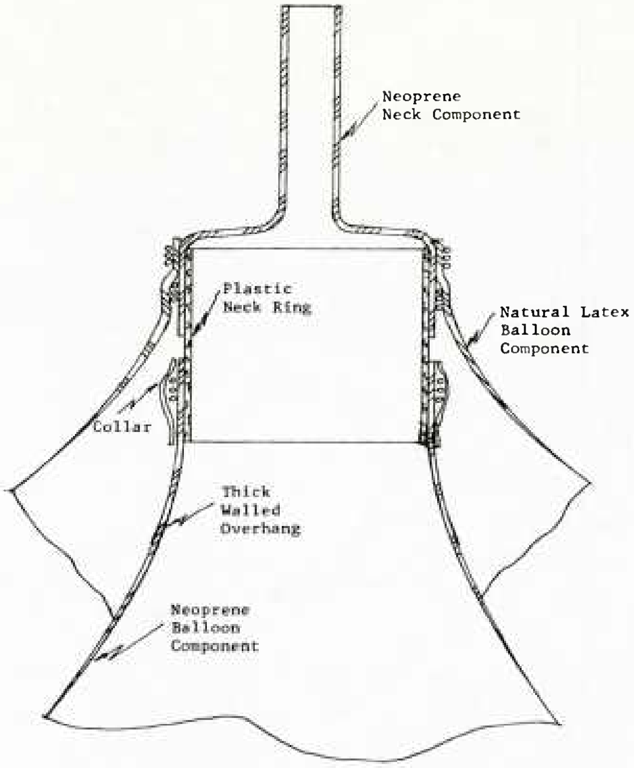

Figure 1 - Sectional View of the Meteorological Balloon Showing the Three Major Components

b. Developed a suitable dipping tank equipped with baffles, screens, funnel and agitator for the natural latex component. This tank was successful in eliminating the formation of slugs, skin, and bubbles on the natural rubber components, and reduced the number of rejects to a low percentage.

c. Eliminated thin areas in the neoprene balloon component which resulted from draping during cure by the process of double draping on three inch bars. Curing racks were fabricated for this purpose. Use of a thixotropic coagulant was not successful in improving neoprene film thickness.

d. Resolved the problem of retalcing balloon components to eliminate sticking of the balloon film to itself by developing a combination inflation-deflation nozzle attached to a blower and dust collector. By operating valves, a balloon can be inflated and deflated with all talc dust exhausted to the dust collector. Balloons processed by this technique showed they were completely free of stuck spots.

e. Precluded inflation problems such as extreme neck streching by increasing the cure of the neoprene neck component and the thickness of the inflation stem.

f. Corrected burst problems by revising the configuration for joining the neoprene and natural latex balloon components to the neck ring.

BENEFITS

The weather balloon is an expendable item. The increased reliability of the new balloon will mean a decrease in the number of flights necessary and therefore will result in a savings to the Government.

As a result of the improved manufacturing method established by this project, a contractor will be capable of producing the improved balloon at a production line rate of 15 per day. (This rate can be expanded to meet military requirements.) The cost of the balloons was reduced from $200 each to approximately $50 each.

IMPLEMENTATION

Upon completion of the project, 200 pilot run balloons were delivered to designated users. A procurement data package including detailed manufacturing specifications and quality control data with production test processes is available for future Army competitive procurement actions.

MORE INFORMATION

Additional information on this project is available from Mr. Wing, Kaysam Corp. of America, Paterson, NJ, AC (201) 525-5400. The contract was DAAB07-74-C-0329.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology projects 475 4395 and 476 4395 titled, "Improved Seating for Military Vehicles" was completed by the US Army Tank-Automotive Research and Development Command in June 1978 at a cost of $300,000.

BACKGROUND

The service life of seats for military vehicles is less than desirable because of the rapid rate of deterioration of the canvas material and associated parts. This necessitates the total replacement of the seats during the life of the vehicle. There also has been acute shortages of canvas material in the past and may be in future years. Industry has done little in the area of molded polyurethane cushions with air-breathing plastic skin. Those seats designed for industry are designed for an enclosed temperature-controlled interior that is not exposed to extreme temperatures, intense sunlight, rain and dust. Therefore, there was not sufficient commerical need or interest for seat materials that could withstand a range of extreme weather conditions. This project was intended to develop suitable seats with savings in labor, material, and maintenance.

SUMMARY

The objectives of these projects were to establish methods and techniques applicable to recently developed compounds which would result in improved military seats. These improvements would include the riding quality of the seat cushions, would provide practical means for field installation of the cushions without major modification to the vehicle, would improve serviceability of the seat cushions, and would achieve cost effectiveness for the cushions. The seats would be fabricated of a one-piece molded polyurethane cushion with air-breathing plastic skin to replace seats currently made of springs, horse hair, rubber and canvas. See Figure 1, next page. There is no sufficient commercial need or interest in this type of seat construction since the seats are designed for different type uses and environments. This program would enable the use of these new materials by solving production problems. Some of these problems are a heat conducting mold capable of removing the surface heat created during the chemical reaction at a rate sufficient to produce an elastomeric skin of sufficient thickness and capable of providing breathability, a method of avoiding both air and water contamination during foam machine processing, and a method for providing and controlling color and thickness.

Figure 1 - Proposed Driver Seat Assembly for 800 Series 5-Ton Vehicle

The effort was conducted in two phases. During Phase I, suitable molds were designed, seats were fabricated, process control measures were established, and laboratory tests were conducted. The laboratory tests were performed to determine comparative physical properties, flexibility at low temperatures, compression deflection, flammability, wear and tear resistance, and to correlate physical property requirements with manufacturing variables. In Phase II, seat assemblies were installed in test vehicles. Field tests were conducted at TECOM test sites having varied climatic conditions. Manufacturing methods and processes with complete fabricating procedures and all technical data necessary for quality assurance requirements were finalized.

BENEFITS

A method for the manufacture of vehicle seats using polyurethane foam and vinyl plastic was developed in this program. These type seats will reduce the dependence on canvas material, and these seats can be contour molded to reduce driver fatigue and can provide more comfort. This type construction can be used in any truck in the Army fleet. The anticipated cost reduction was not achieved due to the increase in the cost of plastics and the current availability of canvas material. An additional benefit is the increased service life of the seat assembly over the assembly currently utilized.

IMPLEMENTATION

The basic objective of these projects was to develop a technique for the manufacture of vehicle seats using polyurethane foam and vinyl plastic materials. This objective was accomplished; however, the results of these projects cannot be implemented due to design deficiencies discovered during field tests. Tests showed that the cushion thickness would have to be reduced, mounting brackets modified, density increased, and cushion base thickness increased.

MORE INFORMATION

Additional information on these projects is available from Mr. Carter Jackson, TARADCOM, AV 273-1728. Reports detailing project efforts are TARADCOM Technical Report No. 12430 titled, "Improved Seating for Military Vehicles" dated Feb. 1979, and Technical Report No. 12211, "The Goodyear Tire & Rubber Company, June 1976, titled "Design, Testing, Fabrication of Molded Neothane Cushions for the M151, M715, M35A2 and 800 Series 5-Ton Trucks".

Summary Report was prepared by the Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project T77 4589 titled, "Metrication" was completed by the US Army Tank-Automotive Research and Development Command in December 1978 at a cost of $271,000.

BACKGROUND

The automotive industry is in the process of converting to metric design. Since this industry is the principal vendor for tank-automotive end items and components, the design of Army items must consider these industries' methods and capabilities for producing them. Also, the interoperability between the United States and European products, which are metrically dimensioned, had to be accommodated. All the investigation, planning and study under this project was directed towards minimizing costs of future tank-automotive end items and parts. Design practices must be modified so that products manufactured for the military are compatible with industry production methods. By doing this, the military can actively participate in the national goal of converting to the metric system.

SUMMARY

The objective of this project was to prepare production and procurement integrity for components and vehicle hardware systems under international metric standards. The time phased plan was based on the industry rate of progress. The majority of military hardware has a commercial base and the facts are that commercial hardware will be produced using the metric system. Metrication planning is required for new acquisition programs because the prime source of hardware components is the commercial industry. This project would insure that DOD would make the conversion to metrics in an orderly manner and with full advantage of all cost saving approaches developed by industry. In the conversion process, low and high production machine tools would be altered to the minimum extent necessary to adapt to manufacture of metric products. The solution to this effort was the preparation of a Metrication Engineering/Design Guide Manual and an Experimental Fabrication Conversion Plan.

BENEFITS

Metrication will contribute to improving the cooperative effort in research, development, production, and procurement of defense equipment. Cost reductions will result when metric size materials and components become commerically available. This is the primary reason the metrication effort is being paced by the United States industrial changeover effort.

IMPLEMENTATION

The Metrication Program is extensive and complex. It cannot be accomplished within a period of one or two fiscal years. The contract with Forecasting International Ltd was completed. The results included an analysis and recommendations for implementation of the Army Metrication Plan. The report was provided to HQ DARCOM. No additional MMT funds were available for follow-on efforts. Funds to implement the Engineering Support Directorate Plan for developing Metric Product Manufacturing Capability was to be programmed as part of the total Command conversion plan.

MORE INFORMATION

Additional information on this project is available from Mr. William E. Lowe, TARADCOM, AV 273-2582.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology projects 574 3049 and 376 3141 titled "Fluidic Manufacturing and Assembly Processes" were jointly conducted by the US Army Research and Development Command and the US Army Missile Research and Development Command. The projects were completed in December 1975 and December 1978 at costs of $170,000 and $270,000 respectively.

BACKGROUND

The use of existing processes for the manufacture of fluidic circuits using miniature fluid amplifiers has been applied only to the extent of showing feasibility. The manufacture of miniature fluid amplifiers in quantity by these processes is new and requires improvements in the processes themselves in order to integrate them into a pilot line. Production costs are high. There is only one firm which is capable of manufacturing diffusion-bonded fluidics in aluminum, three in stainless steel, and one in titanium. Cost savings will be realized with the presence of competition. Cost studies have indicated a large cost savings can be achieved by the development of a new fluidic production capability.

SUMMARY

Fabrication of miniature fluidic systems has been limited to laboratory models, using existing equipment, not specifically designed for production purposes. Quantities fabricated to data have been limited; however, the selected process has been proven to be acceptable. These projects enabled the optimization of the process in a manufacturing environment.

The program was conducted in three phases. In Phase I, the government furnished artwork was converted to usable production tooling and detailed process procedures were developed. Five prototype units were fabricated and tested by engineering personnel to aid in development of the process, test equipment, and artwork. Ten preproduction units were built and tested during Phase II. Phase III included the production cycle in which 100 units were to be produced; however, funding limitations reduced this number to ten units. These units were fabricated using an aluminum structure, assembled, bonded, and tested by production personnel. One unit was environmentally tested in Phase III.

The unit that was used as a test device was a pulse duration modulator (PDM). See Figure 1.

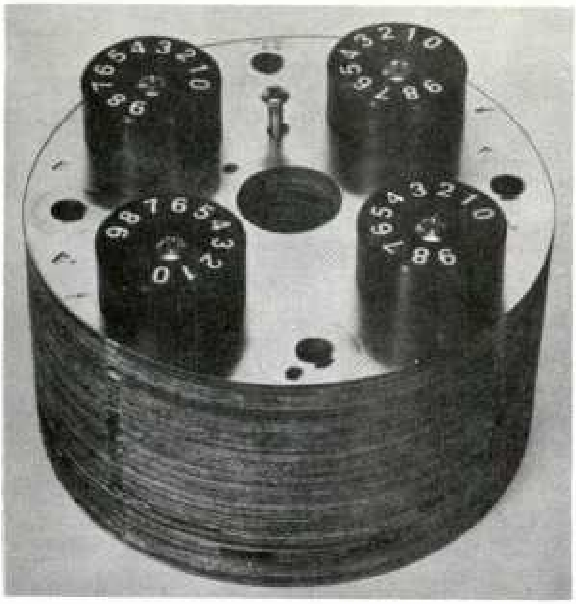

Figure 1 - Completed PDM Unit

The PDM was originally developed for a specific missile application.

The etching process produced high quality laminates with consistent, reproducible results for stock thicknesses up to 15 mils. Nominal nozzle width for the active elements in the PDM was 20 mils. Consistently good results were not obtained when etching 0.030 inch thick stock in production. A typical active element shim is shown in Figure 2.

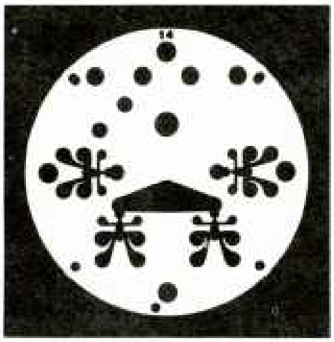

Figure 2 - Typical Active Element Shim

Diffusion bonding of uncoated aluminum alloy shims was obtained with highly consistent results. The important parameters were found to be temperature and surface preparation (deoxidation). Handling of 0.004 thick aluminum shims, especially those containing active elements, was difficult because of the low stiffness of the shims. Operational PDM units were successfully fabricated on a production basis.

BENEFITS

These projects demonstrated that the production of fluidic devices made of aluminum is possible. The techniques and data developed during this program will provide a guideline in the manufacturing of fluidic devices for future munition systems. Production costs were also defined and established.

IMPLEMENTATION

These projects established the baseline for producing fluidic devices and this information will be implemented in future fluidic development programs as the requirements dictate.

MORE INFORMATION

Additional information on these projects is available from Mr. David G. Sampar, ARRADCOM, AV 880-5557/6226 or Commercial (201) 328-5557/6226, or from Mr. J.C. Dunaway, MIRADCOM, AV 746-7626 or Commercial (205) 876-7627. A report prepared by Bendix Aerospace Systems Division entitled, "Fluidic Manufacturing and Assembly Process-Manufacturing Methods", BASD-M6637 dated November 1978 provides the details of the effort. Requests must be referred to Redstone Arsenal, ATTN: DRDMI-TGC, Huntsville, AL 35809.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology projects 672 6681 and 673 6681 titled, "Application of Filament Winding to Cannon and Cannon Components" were completed by the US Army Armament Command in October 1976 at a cost of $200,000.

BACKGROUND

Work under prior MMT funding has shown that a steel wire reinforced epoxy system can be cost effective in the filament winding fabrication of multi-shot recoilless rifles. The present state-of-the-art material for filament windings is high cost high modulus boron and graphite. On the other hand, fiberglass filaments have too low a modulus of elasticity which results in the liner buckling. Therefore, the application of a filament wound steel wire/epoxy composite on a thin-walled titanium alloy liner was considered most feasible for multi-shot light weapons.

These projects were continuing efforts of an original multi-year MMT funded program. They were projects for exploiting and adapting concurrent filament winding techniques to the fabrication of light-weight recoilless rifles and other gun systems.

Project work was accomplished by in-house effort at Watervliet Arsenal and Picatinny Arsenal.

SUMMARY

The objective of these projects was to establish an in-house capability to fabricate cannon tubes using filament winding techniques. These techniques would substitute high strength, high modulus, low density composite materials for conventional gun steel. The approach was to optimize the fabrication parameters of the composite system. This was done by conducting a compatibility study, conducting stress analysis, investigating fabrication techniques, and fabricating cannon specimens for test and evaluation. A versatile filament winding machine was purchased and installed. The machine is a hydraulically controlled, servo-driven unit utilizing a photocontrol programmer. It has great reproducibility over a range of patterns and great flexibility for handling a variety of geometric shapes. The machine is illustrated in Figure 1.

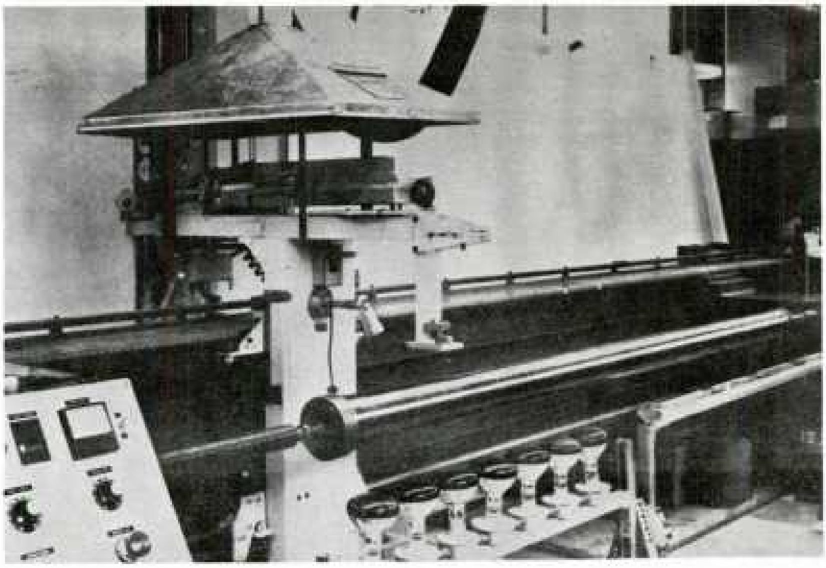

Figure 1 - Overall View of Winder and Wound Composite Tube

Numerous liners for 106MM test cylinders were fabricated. The liners were machined to a number of wall thicknesses, such as 0.050", 0.075", and 0.100". The liners were then wound with a steel filament/epoxy jacket. These were laboratory and field tested. The laboratory specimens were pressure tested to determine the rupture strength. A computer program was developed and used to predict liner deflection and corresponding pressures vs number of winding layers. The test results correlated very closely with the theoretical predictions. The field firing tests consisted of firing 20 inert rounds at a rate of one round per ten minutes. During firing, the projectile velocity, peak pressure, longitudinal and hoop strains, and tube temperatures were recorded. A summary of cylinders tested is shown in Table 1.

Table 1
Summary of Cylinders Tested with Correlation Between Theory and Experimental Data

STATIC TESTS	NL	L_t	J_t	P	ϵ_H	ϵ_L	CTR	A_{11}	A_{12}	A_{22}	A_{66}	E_{HTH}	E_{HEX}
		in.	in.	KSI	%	%		x 10^{-6} in/lb				x 10^6 psi	x 10^6 psi
OCL-5	17	.050	.102	12	.716	.182	-	.499	.078	.262	1.090	25	25.24
OCL-7	14	.100	.084	12	.510	.150	-	.291	.061	.204	.697	26.6	26.6
OCL-7	14	.100	.084	10	.408	.120	-	.291	.061	.204	.697	26.6	26.6
CYCLIC TESTS													
OCL-4	17	.050	.102	12	-	-	1398	.499	.078	.262	1.090	25	-
OCL-6	15	.075	.090	12	-	-	1884	.369	.070	.233	.858	26	-
OCL-10	13	.100	.078	12	-	-	4416	.293	.063	.210	.707	26.7	-
FIRING TESTS													
STUB-106	21	.100	.126	10	.297	-	-	.274	.051	.171	.635	26	-
FULL-106	20	.100	.120	10	.315	.088	-	.277	.052	.175	.643	26	26.1

NL = No. of layers
L_t = Liner thickness
J_t = Jacket thickness
P = Pressure
ϵ_H = Hoop strain
ϵ_L = Longit. strain
CTR = Cycles to failure
A_{ij}^* = Elastic Constants
E_{HTH} = Hoop theo. Modulus
E_{HEX} = Hoop Exp. Modulus

The test results were analyzed to determine the minimum liner wall thickness that can be used and to determine the residual stresses induced into the composite and therefore obtain a more accurate prediction of burst strength.

The design and fabrication accomplishments were completed with the fabrication of a full-size 106MM composite gun tube. The liner was machined to a wall thickness of 0.100" which would give a 30% weight savings over that of a conventional tube. The wall thickness of 0.100" was selected as a result of the fabrication, burst and fatigue data obtained from numerous 106MM test samples. The 0.100" wall is superior in fabrication ease, acceptable liner deflection during winding, fatigue strength and erosion resistance.

BENEFITS

The new manufacturing method developed will permit the fielding of a lighter, more mobile weapon system.

IMPLEMENTATION

The results of these projects were not implemented. In the course of events of these projects, it was argued that other very important areas of studies should be undertaken if composites are to be used in armament components. These recommended areas of studies are included in Technical Report WVT-TR-76035, see below. The experimental and theoretical results of these projects clearly indicate that the filament winding technology developed can be readily used in fabricating any axi-symmetric composite structure.

MORE INFORMATION

Additional information concerning these projects may be obtained from Mr. Robert L. Cullinan, AV 974-5003. Technical Report No. WVT-TR-76035 entitled "Application of Filament Winding to Cannon and Cannon Components-Part III: dated October 1976, Technical Report No. WVT-TR-76052 entitled "Filament Winding of Surfaces of Revolution" dated August 1976, Technical Report No. WVT-TR-75058 entitled "Application of Filament Winding to Cannon and Cannon Components-Part II" dated October 1975, and Technical Report No. R-WV-T-1-7-73 entitled "Minimum Effective Cost Design of Composite Cylindrical Pressure Vessels Related to Gun Tubes" dated February 1973, discuss these projects in more detail.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 673 6808 titled, "Cannon Components Packaging Process" was completed by the Watervliet Arsenal, US Army Armament Material Readiness Command, in December 1974 at a cost of $35,000.

BACKGROUND

Technological advancements in materials and processes for weapons design and production have resulted in lighter, stronger and more corrosion-resistant weapons. Parallel technological advancements are being made in the field of packaging. Methods which utilize these advancements to affect cost savings in packaging mission items warrant investigation. Prior effort into this project areas was funded for $72,000 in 1969 and was completed in 1972.

SUMMARY

The objective of this project was to improve the cannon components packaging process, at a cost savings, using technological advancements where applicable. The project investigated the numerous areas in an effort to improve packaging:

A triple wall stapler was procured and used successfully for fastening the bottom flaps of a triple-wall fiberboard container in less time and for less material cost than the previous method of manually taping the bottom flaps with expensive fiberglass tape.

An automatic steel strapping machine for banding containers was acquired to replace the slower, more laborious hand operated portable strapper, resulting in a time savings of 3 minutes per each container banded.

An automatic electric-pneumatic glue gun was successfully used to replace the time consuming manual taping of blocking within fiberboard containers. A lightweight glue gun which utilized solid glue cartridges was used rather than hot glue reservoir type gun which is more difficult to move and operate. The cartridge gun requires no cleaning, even when switching from one type glue to another since only the nozzle portion is heated. The reservoir type gun requires continual heating of a 5-gallon reservoir and the reservoir must be cleaned when switching from one type glue to another resulting in down-time thus interrupting production time.

The reservoir gun also contributes solvent pollutents to the air while the automatic gun uses 100% solid, non-polluting adhesives.

A portable hand operated graphotype machine used to emboss metal plastic with packaging nomenclature was purchased, replacing an electric graphotype machine which was permanently located in another building. Plates made by this machine are used in an addressograph printing machine which in turn is attached to a stationary automatic packaging machine. The portable machine can be operated by unskilled personnel while the electric machine requires a skilled operator. Savings are realized through elimination of: travel between buildings, waiting time to use the electric machine, processing of work orders as plate changes are required, and delays caused by occasional non-availability of a skilled electric machine operator.

An addressograph front plate feed machine was purchsed and installed to the Pak-Rapid Model HC automatic packaging machine. This machine replaced a labeling machine that printed individual labels, which then were manually glued onto each package. Savings resulted from the quick change feature of removing and inserting different embossed plates in the addressograph machine. This occurs frequently since there is a large quantity of small lots released at this arsenal. Additional savings were gained from the elimination of the manual time previously used in applying labels.

Two types of plastic skin packaging machines were evaluated. One was an automatic and the other was a commercial skin packaging machine. However, the evaluation was terminated, with inconclusive results, when the arsenal obtained two automatic packaging machines which fulfilled skin packaging needs for small quantity production lots.

Three Mortar containers, the 4.2 inch cannon M30 W/E, the 81MM M29A1 W/E, and the 81MM M29A1 were examined with the intent of reducing container sizes through a more economical design, while providing adequate protection to the contents. The review of the containers was made as a result of the auxiliary equipment Basic Issue Item Listing for each mortar being revised to exclude standard stock items.

The 4.2 inch cannon M30 W/E container project effort resulted in no change in the size of the containers.

The 81MM M29A1 W/E container project effort was successful and resulted in redesign of the container, reducing its weight by 30 lbs. as a result of using longitudinal floor boards in lieu of the original crosswise boards, eliminating two longitudinal 2 x 4 inch nominal skids (7 ft. long each), using three traverse skids in lieu of six and eliminating the baseplate hold down.

The 81MM M29A1 container project was successful, resulting in an overall reduction of the container size from the original inside dimensions of 78 1/2 x 22 x 16 1/2 inches to the redesigned smaller 55 1/2 x 22 x 17 1/2 inches. The container design was changed from a special container to a standard PPP-B-621, Style-2 wooden container with logitudinal floor boards in lieu of the orginal crosswise design. The new design eliminated two logitudinal skids, four 2 x 4 nominal spacers, six logitudinal rubbing strips, one upper support and one lower support.

BENEFITS

The project developed new packaging method improvements and designs for various cannon shipping containers resulting in validated overall project cost savings thru 1977 of $35,400.

IMPLEMENTATION

This project was self-implementing at Watervliet Arsenal. Cost savings have been realized over the first four years and savings are expected to continue in the future. A document titled, "Cannon Container Design Guide" was prepared standardizing the design methods and materials for shipping containers.

MORE INFORMATION

Additional information on this project is available from Mr. Ron McCabe, AV 794-5318 or Commercial (518) 266-5318, Watervliet Arsenal, Watervliet, NY 12189.

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 672 6838 titled, "Manufacturing Simplification and Cost Reduction in the Manufacture of Plastic Components of Small Arms and Aircraft Armament" was completed in November 1975 for the US Army Armament Material Readiness Command at a cost of $50,000.

BACKGROUND

Thermosetting plastics have many properties which make their use in weapons systems very desirable. These include excellent resistance to weathering, fungus, low and high temperatures, chemicals, oils and greases; good dimensional stability over a wide temperature range and high compressive and flexural strength. A deterrent to the use of these plastics in weapons systems has been their high cost, compared to thermoplastics. This was basically caused by the fairly long molding times required with the conventional transfer or compression methods. A newly developed injection molding process for thermosets opened up the possibility of these materials competing with thermoplastics.

SUMMARY

The purpose of this project was to simplify manufacturing techniques, lower costs, and to improve the physical properties of various plastic components of small arms and aircraft armament. Prior lead-on projects detailed procedures to obtain stress-free parts. They also resulted in thermoset plastic ASTM test specimens being prepared by two different manufacturing methods, compression molding and injection molding. The parameters finally selected were as follows:

	Phenolics		Epoxies		Polyesters	
	CM*	IM**	CM	IM	CM	IM
Mold Temperature	315°F	330°F	315°F	330°F	280°F	280°F
Molding Pressure	3Kpsi	18Kpsi	2Kpsi	15Kpsi	2Kpsi	15Kpsi
Total Cycle Time	6 min	60 sec	6 min	75 sec	6 min	60 sec

* CM - Compression Molding ** IM - Injection Molding

The total recycle time of injection molding is approximately six times faster than compression molding. This factor leads to potential cost savings. There is also a reduction in flash and material losses.

The next step was to physically test the plastics prepared by the two methods. In nearly all cases, molding fabricated by injection possessed equivalent or superior physical characteristics to those fabricated by the compression method. A very large difference in physical strength improvement between epoxy-glass compounds molded by the different molding techniques was noted which can probably be attributed to the orientation effect of the glass fibers induced by the injection molding method. This was supported by electron microscope photographs.

Besides being consistently stronger, the injection moldings were more dimensionally reproducible than those fabricated by the conventional compression molding method. These superior physical and dimensional qualities are directly related to the following factors:

a. The injection molding cycle is more controllable and consistent than the compression molding, i.e. nine molding variables can be controlled and regulated with a reciprocating screw injection molding machine. The compression molding method is not consistently reproducible because several manual operations are involved.

b. The injection machine meters a homogeneous dispersion of material into the mold cavity, rather than forcing an oversized preformed material slug into the mold cavity.

BENEFITS

The rapid low cost injection molding process using thermoset plastic will result in end items with significantly improved service life over that of the currently used thermoplastics. It is anticipated that the replacement rate of these compounds will be reduced by a factor of 50%.

IMPLEMENTATION

The capability of molding complex nonmetallic moldings that are low cost, dimensionally stable, heat resistant and creep resistant makes the thermoset injection molding process attractive for military applications. These promising results led to the funding of MMT Projects 674 7419 and 675 7419 which developed a specific injection method and to the funding of a Product Improvement Project for the fabrication of M16 handguards.

MORE INFORMATION

Additional information may be obtained by contacting Mr. William Garland at AV 793-5039 or Commercial (309) 794-5039.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 673 7056 titled, "Dewar Materials and Manufacture" was completed by the US Army Armament Material Readiness Command in June 1975 at a cost of $195,000.

BACKGROUND

The newest night vision devices for weapon aiming employ exotic and expensive infrared detectors. They become effective at temperatures of around -196^{o}C (77^{o}K). Hence, they are housed in high vacuum dewars and integrated with miniature cryogenic refrigerators.

High vacuum dewars not only insulate detectors from surrounding heat, but also prevent contamination resulting from solid-gas interaction. Loss of vacuum through outgassing of materials inside the dewar or through loss of vacuum integrity of the dewar walls causes detector failure. Once vacuum integrity is lost, it is extremely difficult to salvage the infrared detectors. Vacuum failure can result in existing detector/dewar systems six to eight months after units are sealed off.

SUMMARY

An engineering study was made to investigate materials and fabrication processes which will enhance the operational lifetime of these dewar systems. Failure analysis was performed which included mass spectroscopic analysis of outgassed products to identify the sources of outgassing. Material finishing methods and high temperature bake-out techniques were investigated. An analysis of various "getter" materials on their effectiveness to "getter" molecules present in the surrounding space was performed. Metal joining techniques were investigated to provide better methods of providing dewar wall integrity in order to minimize leakage.

From this study, a permanently sealed metal dewar was designed as shown in Figure 1 to house the linear array. This design more than doubled the operational lifetime. This is a significant milestone for sealed metal dewar systems for high density mercury-cadmium-tellurium detectors. Such dewars are capable of maintaining high vacuum integrity for a year or more without active vacuum pumping.

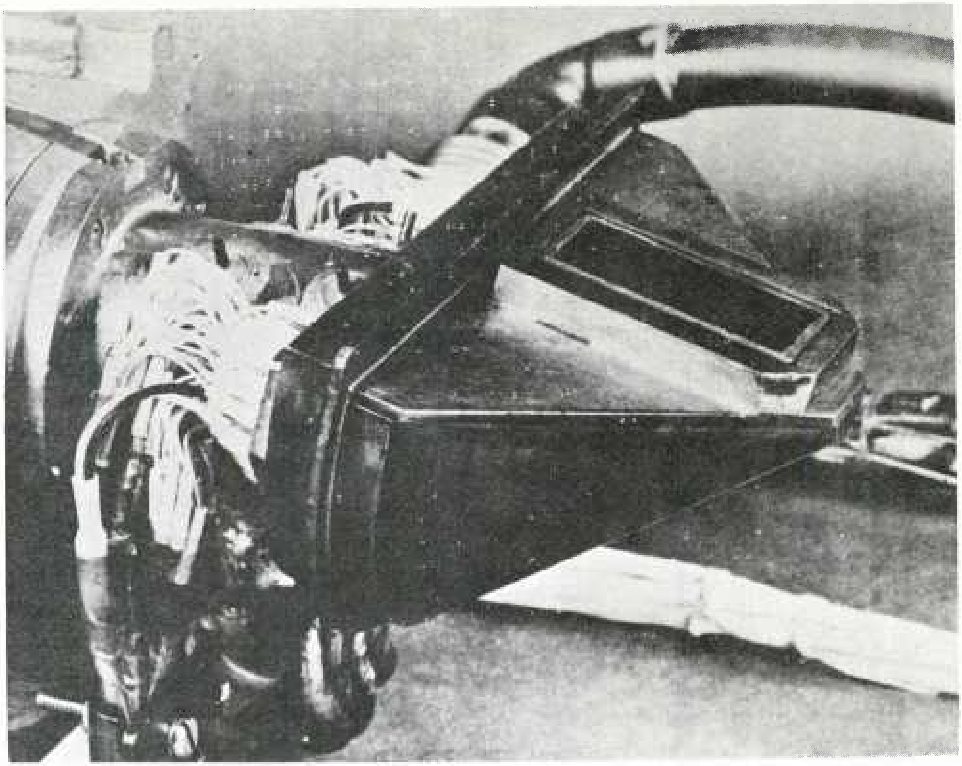

Figure 1 - Sealed Metal Dewar

This project also established methods for manufacturing a demountable dewar that can be separated for repair or replacement of internal instrumentation. Then, when resealed, it will perform within original specifications. Major problems overcome on this project were the method of achieving proper groove configuration and preparing and inserting a seal so as to achieve specified leak rate tolerance after bake-out.

For those applications where demountable dewars are preferred, various seals were investigated. Indium was selected because its sealing forces are low and therefore do not require large bolts and flanges. Other advantages are low outgassing and permeation, and high malleability which permits its use in complex configurations.

The report for this project describes several tests that were developed for evaluating performance of detector arrays and evaluating the reliability of metal dewars. A discussion on selecting proper materials is presented as well as the fabrication procedure to construct them. Criteria has been established for determining the minimum leak rate, outgassing rate, and permeation rate needed for a particular dewar to maintain a certain operational lifetime. Also included is a design for the use of indium seals for demountable dewars.

BENEFITS

The concept of demountable dewars will double the operational lifetime of infrared fire control services as well as the facilities system assembly. This will cut replacement costs accordingly. The results of this project will be applicable to all types of fire control instruments in the AMP related to ANA/AQ5, FLIR (Forward Looking IR); the M60A3 tank; and the A6H system proposed for Grumman aircraft.

IMPLEMENTATION

A production process has been written in report form for both internal use and distribution to other agencies within the government. The basic procedure of improved process control is being applied to dewar manufacture. No new equipment was required.

MORE INFORMATION

Additional information on this program may be obtained from Mr. Joseph Lehman, ARRADCOM, AV 880-2064 or Commercial (210) 328-2064. The Report No. is FA-TR-75086 dated June 1975. It is titled "Evaluation of Sealed Metal Detector Dewars for Fire Control Systems".

Summary Report was prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 674 7419 titled, "Low-Cost Reciprocating Screw Molding of Thermosetting Plastic Weapons Components" was completed by the US Army Armament Command in March 1977 at a cost of $65,000.

BACKGROUND

Until recently, thermosetting plastic weapons components could not be produced because of the high cost associated with the only molding technique then available. That technique was transfer and compression. The possibility of producing low-cost functional thermosetting plastic weapons components becomes feasible and attractive with the advent of the reciprocating screw injection machine. Many non-metallic components and accessories could be reduced in cost and improved in quality if this new process could be perfected.

SUMMARY

The objective of this project was to provide manufacturing procedures for the fabrication of weapons components and accessories utilizing the new injection molding process for thermosetting plastics. Data would be obtained to establish detailed processing specifications. Prototype weapons components such as rifle hand guards, trigger guards, and magazines manufactured by this technique would be evaluated to determine their serviceability in comparison to standard end items. The initial efforts would include the procurement of applicable thermosetting materials, preparation of component molds and the establishment of processing procedures for the various materials.

The in-house mold temperature control unit was found to be inadequate for thermoset plastic moldings due to its limited heating capacity of 250°F. A new process controlled reciprocating screw thermoset molding machine was purchased. Two additional monitoring modules were installed; one was used to measure the cavity mold temperature and the other was used to monitor the post-gate material molding pressure. Selective engineering plastics were molded to establish the operational parameters of the control systems. The test cavity mold was modified to mold thermosets. The closed-loop cavity pressure control system was evaluated to determine how effective the system would be in the control of mold flashing. With all machine controls remaining constant, twelve test specimens ranging in size from 0.075 to 0.390 inches thick were molded

in the adjustable depth test cavity mold. The results indicated that the inherent thermoset molding flash problem should be substantially reduced or eliminated with the closed-loop cavity pressure regulator system.

BENEFITS

The results of this program provided the Army with the potential for a manufacturing capability to produce high quality thermoset plastic weapons components with a significantly improved service life over that of the currently compression molded end items. Also cost reductions resulting from the use of thermoset injection molding would be significant.

IMPLEMENTATION

Prior to implementing the results of this program, a second year of effort will be required. This effort would include optimizing the processing parameters, and fabricating and evaluating weapon components to determine their serviceability. Due to the phase-out of Rodman Laboratory and the lack of additional funding, the second year effort was not undertaken.

MORE INFORMATION

Additional information concerning this project may be obtained from Mr. John R. Cerny, AV 793-5039 or Commercial (309) 794-5039.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 675 7581 titled, "Fabrication of Weapons Components from Microcellular Foam" was conducted by the US Army Armament Command during the period of October 1974 to December 1976 at a cost of $35,000.

BACKGROUND

This project was initiated to develop a process for fabricating weapon components from microcellular foam. The objective was to develop the capability to fabricate lightweight, low cost weapon components from both rigid and flexible microcellular materials. It would provide the ability to fabricate weapon components having increased reliability at reduced cost. It would also permit new engineering concepts to be incorporated into weapon design. Examples of weapons components are rifle butt stocks, butt pads and artillery handwheels. Developing a process for the use of microcellular foam would permit the replacement of the current manufacturing processes which require relatively more expensive materials and tooling.

SUMMARY

During the early part of the program, a preformulated and prepackaged kit of polyurethane foam supplied in pressurized containers with a mixing head was evaluated. Nonreproducibility was noted in the quality of foam supplied from shot to shot. A primary cause for this variance was the poor metering of the two component streams. A second disadvantage of this system was a lack of provision for supplying preset or measured shot size.

A buttstock mold was fabricated for the Squad Automatic Weapon (SAW) which was used as a test vehicle for this project. A batch type mixing process using a high speed stirring motor and paint mixer was evaluated using a rigid foam system. When the foam was mixed using this process, a poor rise was obtained, probably due to insufficient mixing of the foam components or to deterioration of the foam during storage.

A batch type mixing process using a blender was used to fabricate a SAW buttstock from a rigid microcellular urethane having a density of 35 lbs/ft^3. Pigment dispersion proved to be a problem. Also, some effort was required to determine the level of black pigmentation required to obtain good coloration. Microcellular foam appeared to require a greater quantity of pigment than non-foamed urethane to achieve coloration.

A commercially available black pigmenting agent and one prepared by blending 50 parts by weight of a thermal carbon black with 50 parts by weight of a plasticizer were evaluated. The commercial pigment was found to have the least effect on the expansion properties of the foam system in which the pigments were evaluated. Various levels of pigment were evaluated and two parts per hundred resin appeared to be the minimum required for good coloration. Mold temperatures were varied between 40°F and 100°F to evaluate the effect of temperature on skin formation of the foam. A temperature of 75°F or less was found to be the most desirable for skin formation with skin thickness increasing as the mold temperature was lowered.

Prototype SAW buttstocks were fabricated for evaluation. The evaluation was not conducted nor were process specifications finalized due to the transfer of the mission and subsequent phase-out of Rodman Laboratory.

BENEFITS

The potential benefits that could have resulted if this program would have been completed successfully were: (a) the capability to fabricate lightweight, low cost weapon components from both rigid and flexible microcellular materials and (b) the fabrication of weapon components having increased reliability at reduced cost.

IMPLEMENTATION

This project was not completed; therefore, it was not implemented.

MORE INFORMATION

Additional information on this project is available from Mr. W.M. Veroeven, ARRCOM, AV 793-4119 or Commercial (309) 794-4119.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology project 677 7747 titled, "Injection Molded Plastic Foams for Small Arms" was conducted by the US Army Armament Command during the period of October 1976 to June 1977 at a cost of $70,000.

BACKGROUND

The current M16 rifle stock consists of a fiberglass reinforced thermoset plastic outer shell with a polyurethane foam core. Manufacturing costs are high since two molding operations are required: compression molding and liquid polyurethane foaming. In addition, the field serviceability of the butt stocks is poor due to the high breakage rate. The breakage problem results from the inherent inelastic character of the phenolic resin. This program was needed to investigate both thermoplastic and thermoset structural-foam molding techniques in which the entire butt stock with rigid cellular core and a solid integral skin could be fabricated from one material in a single injection molding operation.

SUMMARY

A study was conducted of commerically available plastic materials that are injection moldable and that can be foamed. ABS plastics are likely candidates for this application. Cycolac JP, manufactured by Borg-Warner Corporation, is an example of a foamed ABS plastic. Another candidate is polypropylene plastic.

An investigation was initiated but not completed on the most important processing variables that could influence the production of faultless M16 butt stocks using a foamed plastic. Very close control of screw speed, back pressure, injection pressure and stock temperature must be maintained in order to produce good parts by injection molding.

A study was made of the feasibility of using an existing steel, one-cavity mold instead of designing a new one. The mold was previously used in the casting of liquid urethane butt stocks. Although major changes to the mold would have to be performed to adapt it to an injection molding machine, this plan appeared to be feasible and less costly than making a new mold.

Engineering design requirements for the butt stock, injection molded from a foamed plastic, were determined and are documented in a work summary report.

BENEFITS

The potential benefits from this program could have been significant manufacturing cost savings since one molding operation would be eliminated and the injection molding method would replace the time consuming compression molding technique. Another potential benefit would be improved field serviceability and durability of the butt stocks.

IMPLEMENTATION

The results of this project have not been implemented since the project was not completed. The project was transferred to ARRADCOM during the phase-out of Rodman Laboratory. Additional work could not be conducted to complete the project due to insufficient funding.

MORE INFORMATION

Additional information on this project is available from Mr. Charles C. Wright, ARRADCOM, AV 880-3469 or Commercial (201) 328-3469.

Summary Report prepared by Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

APPENDIX I

ARMY MMT PROGRAM OFFICES

ARMY MMT PROGRAM REPRESENTATIVES

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AV: 284-8284/8298

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AV: 793-5113

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US Army Armament R&D Command
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AV: 880-6714

ARRCOM
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US Army Aviation Systems R&D Command
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AV: 698-6476

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AV: 995-4262

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AV: 995-4829

MERADCOM
US Army Mobility Equipment R&D Command
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AV: 354-4221

MICOM US Army Missile Command ATTN: DRDMI-EAT, Mr. Ray Farrison Redstone Arsenal, AL 35809	C: 205 876-1835 AV: 756-1835
NARADCOM US Army Natick R&D Command ATTN: DRDNA-Z, Mr. Edward F. Levell Natick, MA 01760	C: 617 653-1000, x2793/4 AV: 955-2349/2351
TARADCOM US Army Tank-Automotive R&D Command ATTN: DRDTA-KP, DRDTA-RCK, Mr. J. Chevalier Warren, MI 48090	C: 313 573-2065/1814/2467 AV: 273-2065
TARCOM US Army Tank-Automotive Materiel Readiness Command ATTN: DRSTA-EB, Mr. Basel Armstead Warren, MI 48090	C: 313 573-2485 AV: 273-2485
TECOM US Army Test & Evaluation Command ATTN: DRSTE-ME, Mr. Grover Shelton Aberdeen Proving Ground, MD 21005	C: 301 278-2170/3677 AV: 283-2170/3677

APPENDIX II

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HQDA, ODCSRDA, The Pentagon, Attn: DAMA-PPM-P, Mr. Rod Vawter

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PM, Automatic Test Support Systems, Attn: DRCPM-ATSS (CORADCOM)
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PM, Cannon Artillery Weapons Systems, Attn: DRCPM-CAWS (ARRADCOM)
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PM, CHAPARRAL/FAAR, Attn: DRCPM-CF (MICOM)
PM, Chemical Demilitarization & Installation Restoration, Attn: DRCPM-DR (APG)
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PM, Division Air Defense (DIVAD) Gun, Attn: DRCPM-ADG (ARRADCOM)
PM, Family of Military Engr. Construc. Equip. (FAMECE)/Univsl. Engr. Tractor (UET), Attn: DRCPM-FM (MERADCOM)
PM, Fighting Vehicle Armament, Attn: DRCPM-FVA (TARADCOM)
PM, Fighting Vehicle Systems, Attn: DRCPM-FVS (TARADCOM)
PM, FIREFINDER, Attn: DRCPM-FF (ERADCOM)
PM, General Support Rocket System, Attn: DRCPM-RS (MICOM)
PM, Ground Laser Designators, Attn: DRCPM-LD (MICOM)
PM, HAWK, Attn: DRCPM-HA (MICOM)
PM, Heavy Equipment Transporter (HET), Attn: DRCPM-HT (TARCOM)
PM, Heliborne Laser Fire and Forget (HELLFIRE) Missile System, Attn: DRCPM-HE (MICOM)

Project/Product Managers (Cont'd):

PM, High Energy Laser System, Attn: DRCPM-HEL (MICOM)
PM, Improved TOW Vehicle, Attn: DRCPM-ITV (TARADCOM)
PM, LANCE, Attn: DRCPM-LC (MICOM)
PM, M60 Tank Development, Attn: DRCPM-M60TD (TARCOM)
PM, M60 Tank Production, Attn: DRCPM-M60TP (TARCOM)
PM, M110E2, 8-Inch Howitzer, Attn: DRCPM-M110E2 (ARRCOM)
PM, M113/M113A1 Family of Vehicle Readiness, Attn: DRCPM-M113 (TARCOM)
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PM, 2.75 Rocket System, Attn: DRCPM-RK (MICOM)
PM, SATCOM, Attn: DRCPM-SC (ERADCOM)
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PM, Stand-off Target Acquisition System, Attn: DRCPM-STA (ERADCOM)
PM, STINGER, Attn: DRCPM-MP (MICOM)
PM, TOW-DRAGON, Attn: DRCPM-DT (MICOM)
PM, Training Devices, Attn: DRCPM-TND (Orlando, FL)
PM, US ROLAND, Attn: DRCPM-ROL (MICOM)
PM, VIPER, Attn: DRCPM-VI (MICOM)
PM, XM-1 Tank System, Attn: DRCPM-GCM (TARADCOM)

Project Officers:

PO, M60A1 Tank Camouflage Pilot Program, Attn: DRXFB-RT
PO, SLUFAE/SLUMINE, Surface Launch Unit Fuel Air Explosive (SLUFAE) Mine Neutralization System/Surface Launched Unit Mine (SLUMINE) Dispensing System, Attn: DRDME-NS (Ft. Belvoir)
PO, Stand-Off Target Acquisition/Attack System (SOTAS), Attn: DRSEL-CT
PO, Test, Measurement, and Diagnostic Equipment, Attn: DRCRE-T (DARCOM)
PO, Tactical Shelters, Attn: DRXNM-UBS

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Cdr, ARRADCOM, Attn: DRDAR
Cdr, ARRADCOM, Attn: DRDAR-TDA, Mr. Joe Blick
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Depots (Cont'd)
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Cdr, Army Weapons Support Ctr, Crane, IN 47522
Cdr, Foreign Science and Technology Ctr. (FSTC), Attn: DRXST-OC
Dir, Installations and Services Activity (I&SA), Attn: DRCIS
Cdr, Night Vision Labs (NVL), Attn: DRSEL-NV-PA/IO

MT Representatives:
Cdr, ARRCOM, Attn: DRSAR-IRB, Mr. August Zahatko (8 cys)
Cdr, AVRADCOM, Attn: DRDAV-EXT, Mr. Robert Vollmer
Cdr, CERCOM, Attn: DRSEL-LE-R, Mr. Martin Ides
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Cdr, HDL, Attn: DELHD-PP, Mr. Julius Hoke (3 cys)
Cdr, AMRDL, Attn: SAVDL-EU-TAS, Mr. L. Thomas Mazza (3 cys)
Cdr, RIA, Attn: SARRI-ENM, Mr. Joseph DiBenedetto (3 cys)
Cdr, WVA, Attn: SARWV-PPI, Mr. L.A. Jette (3 cys)
PM, MPBM&E, Attn: DRCPM-PBM-DP, Mr. Joseph Taglairino (5 cys)
DCSRDA, Attn: DAMA-WSA, LTC Jay B. Bisbey (2 cys)
DCSRDA, Attn: DAMA-WSM-A, Mr. John Doyle (2 cys)
DCSRDA, Attn: DAMA-WSW, MAJ Gordon Winder (2 cys)
DCSRDA, Attn: DAMA-CSC-BU, COL Higgins (2 cys)
DCSRDA, Attn: DAMA-CSS-P, LTC L. R. Hawkins, LTC P. K. Linscott (2 cys)
DCSRDA, Attn: DAMA-CSM-P, Mr. John Mytryshyn (2 cys)
DCSRDA, Attn: DAMA-CSM-DA, COL Jack King

Navy Activities: (2 cys each)
Cdr, NAVMAT, Attn: CPT L. C. Dittmar, Code 064
Cdr, NAVMIRO, Attn: Officer-In-Charge
Cdr, NAVSEA, Attn: T. E. Draschil, Code C-0354
Cdr, NAVAIR, Attn: D. S. Henderson, Code ESA-824
Cdr, NAVELEX, Attn: C. A. Rigdon, Code ELEX-504512
Cdr, Naval Surface Weapons Ctr/White Oak Lab, Attn: Code E-1A, Mr. Banish
Cdr, Naval Surface Weapons Ctr/Dahlgren Lab, Attn: Code CM-51
Cdr, Naval Weapons Ctr, Attn: D. M. Bullat, Code 36804
Cdr, Naval Ordnance Station, Attn: C. Johnson, Code NOSIH/281

Air Force Activities:
Cdr, HQ, USAF/RDXI, The Pentagon, Attn: MAJ D. Mackintosh
Cdr, AFSC/DLF, Andrew AFB
Cdr, AFSC/DLFF, Andrew AFB
Cdr, AFSC/PPD, Andrew AFB
Cdr, AFSC/PPDE, Andrew AFB
Cdr, AFML/LT, Wright-Patterson AFB
Cdr, AFML/LTE, /LTM, /LTN, Wright-Patterson AFB
Cdr, AFML/MX, Wright-Patterson AFB
Cdr, San Antonio Air Logistics Ctr, Kelly AFB, Attn: E. Boisvert, MMEWA

Professional Societies: (5 cys each)
Electronic Industrial Association
Attn: Mr. Jean Caffiaux, 2001 I St., N.W., Washington, DC 20006
Numerical Control Society
Attn: Mr. Ron Hunt, 1800 Pickwick Avenue, Glenview, IL 60025
Aerospace Industries Association
Attn: Mr. Robert Worthen, Col, US Army (Ret), 1725 Desales Street, N.W., Washington, DC 20036
American Defense Preparedness Association
Attn: Mr. Rudolph Rose, Col, US Army (Ret), 740 15th Street, N.W. Suite 819, Washington, DC 20015
Society of Manufacturing Engineers
Attn: Mr. Bernard Sallot, One SME Drive, P.O. Box 930, Dearborn, MI 48128
American Institute of Industrial Engineers
Attn: Mr. Mikell Groover, Packard Lab #19, Lehigh University, Bethleham, PA 18015
Forging Industry Association
Attn: Mr. C. G. Scofield, Room 1121, 55 Public Square, Cleveland, OH 44113
American Society for Testing and Materials
Attn: Mr. Samuel F. Etris, Special Assistant, 1916 Race Street, Philadelphia, PA 19103
Cast Metal Federation
Attn: Mr. William E. Gephardt, Chairman, Govt. Supply Committee, 4870 Packard Road, Niagara Falls, NY 14304